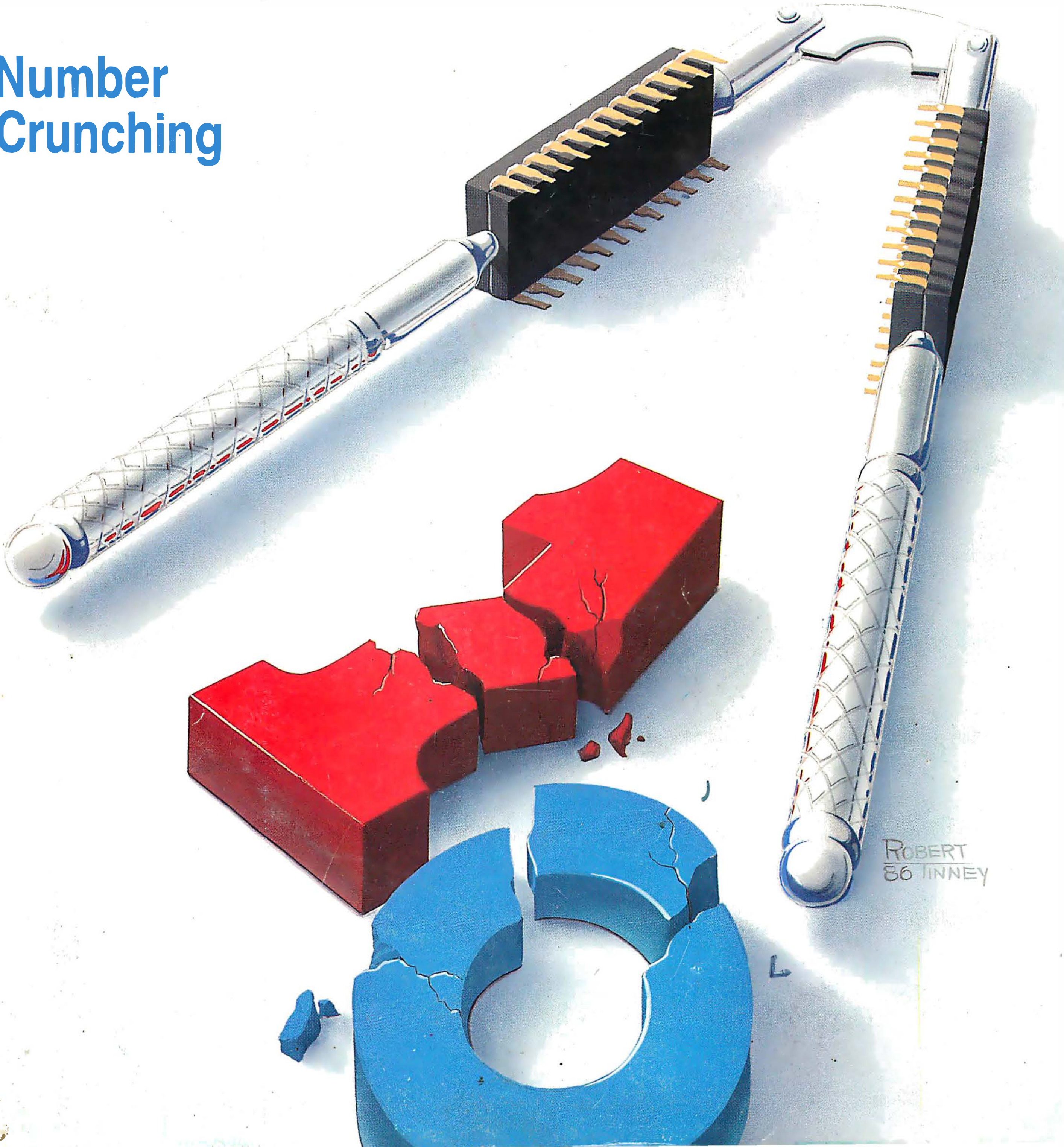
BYTE

THE SMALL SYSTEMS JOURNAL®

APRIL 1986 VOL. 11, NO. 4

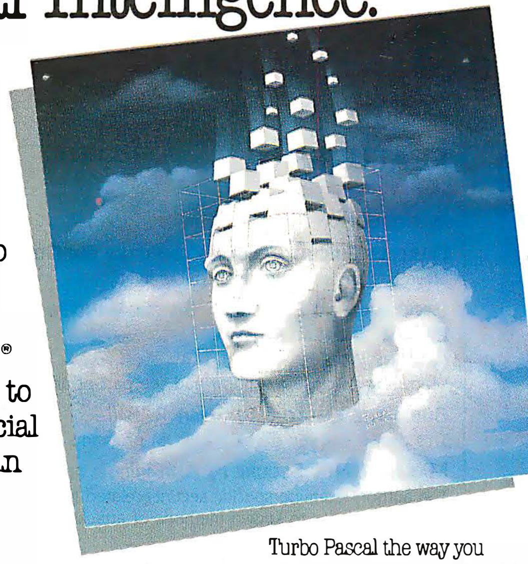
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Turbo Prolog 1.0 Technical Specifications
Programming System Features

Compiler: Incremental compiler generating native in-line code and linkable object modules. The linking format is compatible with the PC-DOS linker. Large memory model support. Compiles over 2500 lines per minute on a standard IBM PC.

Interactive Editor: The system includes a powerful interactive full-screen text editor. If the compiler detects an error, the editor automatically positions the cursor appropriately in the source code. At run-time, Turbo Prolog programs can call the editor, and view the running program's source code.

Type System: A flexible object-oriented type system is supported.

Windowing Support: The system supports both graphic and text windows.

Input/Output: Full I/O facilities, including formatted I/O, streams, and random access files.

Numeric Ranges: Integers: −32768 to 32767; Reals: 1E−307 to 1E+308.

Debugging: Complete built-in trace debugging capabilities allowing single-stepping of programs.

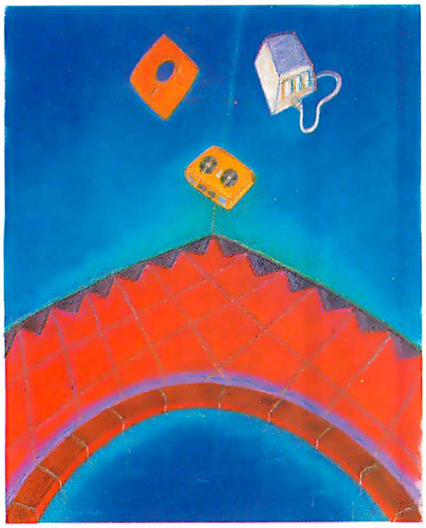
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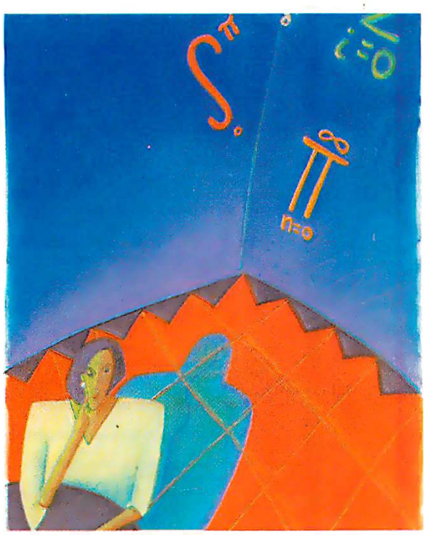
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THEME: NUMBER CRUNCHING



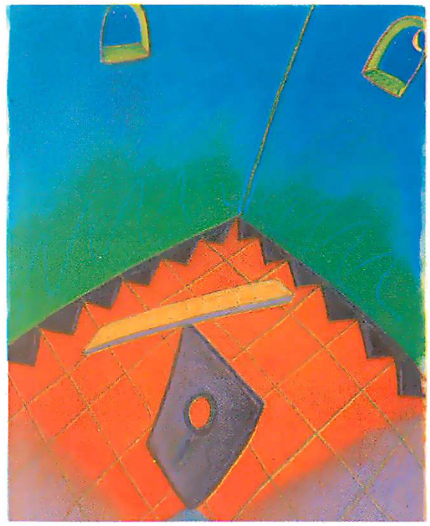
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REVIEWS

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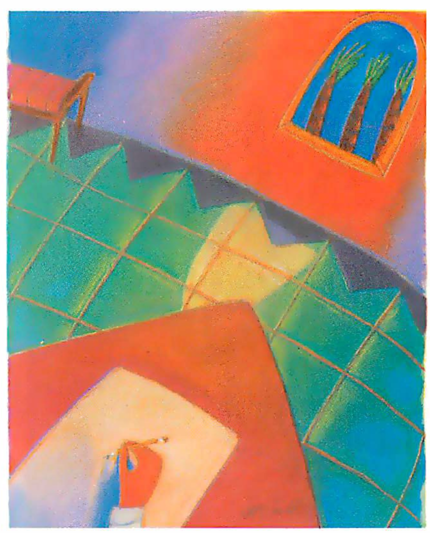
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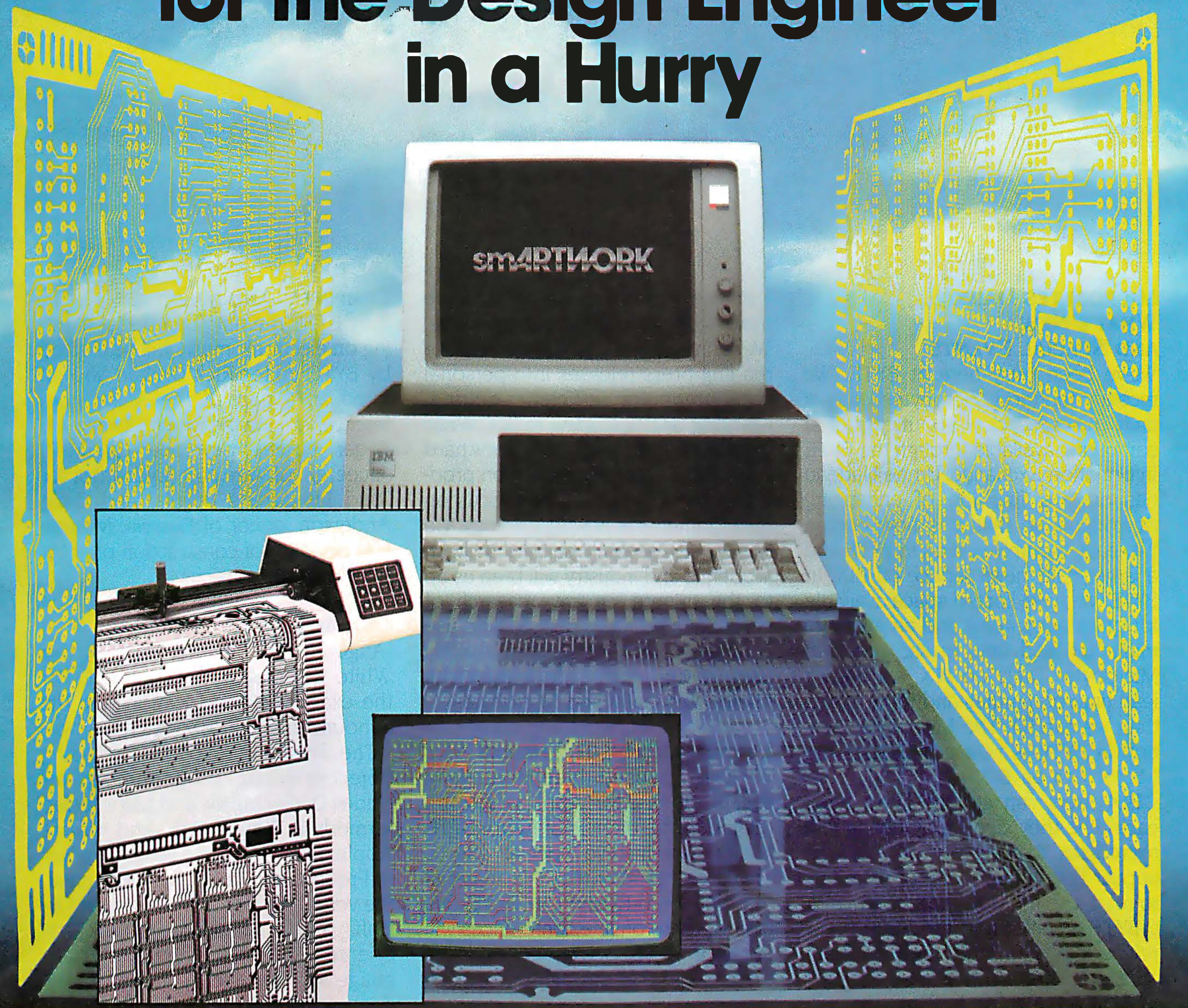
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MICROBYTES DAILY, WHAT'S NEW, AND SPECIAL EVENTS

We've been busy here at BYTE. We recently founded Microbytes Daily, a daily news service about personal computing available through the BYTE Information Exchange. Lynne Nadeau has done a fine job of enhancing Microbytes so that it is now both a two-page monthly section in BYTE and a larger daily news service on BIX. In BYTE, we have limited space available for quick news items and an absolute minimum lead time of six weeks. In Microbytes Daily on BIX, we have a lead time of minutes and more space than we can fill. The Microbytes section in BYTE is now a subset of the Microbytes on BIX.

BIX users can get the latest news each time they sign on by typing join microbytes. To make Microbytes always appear first in the queue of materials to read, use the BIX order command.

BYTE receives 2400 to 3000 press releases each month, most of them announcing products. We try to select from all these releases those that will be of greatest interest to most BYTE readers. Thanks to the extra efforts of Dennis Barker and Cathy Baskin, who regularly edit What's New, we now have much greater scope: the "whats.new.hard" and "whats.new.soft" conferences on BIX. By joining those two conferences, BIX users can see a large selection of product announcements divided into hardware and software. Topics in the conferences provide subdivisions such as software for specific machines. You can also use the BIX search command to look for announcements that contain specific terms of interest to you. The familiar What's New will continue to appear in BYTE as before. Now the print What's New will be a subset of the on-line whats.new.hard and whats.new.soft.

In time, we hope to make the on-line news services truly comprehensive. We're investigating OCR devices for reading press releases into personal computers for efficient editing, rewriting, and uploading to BIX. While whats.new.soft and whats.new.hard will continue to concentrate on products, Microbytes Daily will focus on developments in new technology. We hope that research centers in both academia and industry will keep us up to the minute on any research of potential interest to people who use computers so that we can quickly pass along such information via Microbytes Daily and Microbytes.

EVENTS AND ISSUE THEMES

We have arranged three month-long events on BIX for April, which are related to the themes of future BYTE issues and involve special guests. These events may result in material that will be published in BYTE. We believe these on-line conferences will enhance BYTE's coverage of issue themes and that through BIX we can learn more about what BYTE readers want in the way of theme coverage. We will use some upcoming articles to stimulate discussion in conferences on BIX.

The relationship of the BIX special events to BYTE issue themes is indicated in parentheses.

OPTICAL STORAGE

(May BYTE theme is mass storage.) BYTE editor Ken Sheldon will be moderating this special event. Check the system.news conference on BIX for the exact title and location. Some of the experts invited to discuss CD-ROMs are William Zoellick, manager of Software Research for TMS Inc.; William Casey, president of Advanced Storage Concepts; and Tim Oren of Activenture.

COMPUTERS AND MUSIC

(July BYTE theme) The special meeting on electronic music will be chaired by BYTE editor Rick Grehan and offered as a part of the Music conference. Among the experts invited are Roger Powell, developer of MIDI squeezer software and keyboardist for Todd Rundgren's Utopia, and Craig Anderson, editor of *Electronic Musician* and designer of construction projects for electronic musicians.

OBJECT-ORIENTED LANGUAGES

(August BYTE theme) BYTE's Eva White will moderate this event. For the exact title and location, see the announcement in BIX system.news.

The lineup of experts discussing object-oriented programming includes Daniel Ingalls and Larry Tesler, formerly at Xerox PARC and now at Apple; Brad Cox and Kurt Schmucker of Productivity Products International, the vendor of Objective-C; Charles B. Duff, author of Neon, an object-oriented extension to the FORTH language for the Macintosh, and president of the Whitewater Group; Jeremy Jones of Coral Software and one of the designers of Object Logo; Bjarne Stroustrup of Bell Labs and designer of C++; and Jim Anderson, president of Digitalk, which developed Methods, a Smalltalk development environment for the IBM PC.

We hope to see you on line for these events and the more than 100 other conferences on BIX. If you prefer not to participate in telecommunications, however, we still expect that you'll benefit from BIX events and conferences because direct interaction with readers and technical experts will help the BYTE staff plan and prepare better issues.

—*Phil Lemmons*
Editor in Chief


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M·I·C·R·O·B·Y·T·E·S

Staff-written highlights of late developments in the microcomputer industry.

Visi On Is Back On

Remember Visi On, the highly touted integrated program for the IBM PC? Control Data Corporation purchased the program from the now-defunct VisiCorp about a year and a half ago. CDC has been busy retooling the product and now is almost ready to rerelease it, according to a spokeswoman at the firm's Business Information Services division in Minneapolis, MN.

"What we've done is enhance the applications manager [the central controlling component of Visi On] and the individual applications," said the CDC spokeswoman. "We recognize people have favorite DOS packages, so we're positioning [Visi On] as a value-added package." Each Visi On application will be priced at $150, as will the applications manager. The minimum suggested configuration to run Visi On is an IBM PC with a hard disk and 512K bytes of RAM. Visi On came out at a time when most PC users were still adjusting to the idea of hard disks and 256K RAM. CDC hopes that Visi On will get a better reception than it did earlier now that more powerful PCs are the norm.

Customers will be able to purchase Visi On directly through a still-unannounced 800 number and various value-added retail channels.

Intel Controller for 8/16-bit Programmable Bus

Intel Corporation of Santa Clara, CA, announced what it calls the first 16-bit microcontroller that lets a system's external data bus be programmed at 8 bits, 16 bits, or both. The first implementation of this controller is an EPROM chip called the 8796BH, which is designed for prototypes and low-volume production where software is not yet complete. The 8796BH is priced at $75 in quantities of 1000. A ROM version of the chip, called the 8396BH, will sell for $9.96 in 25,000-unit quantities. The chips will be available in the second quarter and second half, respectively, of 1986.

Demonstration of Project Andrew for 3M Computers

Carnegie-Mellon University of Pittsburgh, PA, has given the first hands-on demonstration of its nascent Project Andrew educational-software system. Andrew is expected to run on so-called 3M computers. The 3M specification refers to a computer with a minimum of 1 megabyte of RAM, processor speed of 1 million machine instructions per second, and screen resolution of 1000 by 1000 pixels. (However, Andrew does run on the IBM RT PC, which has a screen resolution of 1024 by 750 pixels.)

The Project Andrew system runs on top of UNIX 4.2 and is designed so that applications written for it will be transportable across different hardware systems. Although Project Andrew will not be completed for another year, a Carnegie-Mellon official said that at least one major hardware vendor (and perhaps several) is expected to announce 3M computers within the next 12 months.

A number of vendors (IBM and DEC chief among them) have contributed to the CMU project. Apple Computer has stated that it plans to participate in the 3M market. That market has also been targeted by Next Inc., a start-up firm headed by former Apple chairman Steven Jobs.

Intel and Interactive Systems Will Port UNIX V to 80286/80386

Intel Corporation of Santa Clara, CA, and Interactive Systems Corporation of Santa Monica, CA, have agreed to port AT&T's latest version of UNIX System V to the 80286 and 80386 microprocessors. According to George Alexy, Product Marketing Manager of Intel's

(continued)

Microprocessor Division, "The inherent ability of the 80386 means that, when combined with UNIX System V, the system will support the current base of MS-DOS applications." Interactive had previously ported its UNIX System V product, IN/ix, to the entire iAPX86 line of microprocessors.

Borland's Modula-2 for the Apple II and Turbo Pascal for the Mac

At the MacWorld Exposition in San Francisco, Borland International of Scotts Valley, CA, demonstrated its new Turbo Modula-2 on an Apple IIe with a Z80 coprocessor card running CP/M. The language is scheduled to ship during the second quarter of this year. It won't be available just to Apple owners; Borland plans to support it for all the same CP/M (2.2 or higher) computers that are already served by Turbo Pascal. And the firm claims that it will sell an MS-DOS version in the second half of the year.

Turbo Modula-2 includes a WordStar-style editor similar to that of Turbo Pascal. The main menu lets you choose to compile directly to native code or to interpreted m-code. Another menu selection lets you either accept Borland's extensions to Modula-2 or stick with the Wirth definition of the language.

Borland also announced that it will begin shipping Turbo Pascal for the Macintosh in the second quarter of 1986. The language was not demonstrated at the exposition.

ADAPSO Pushes Software-Protection Scheme

Eight hundred million dollars. That's about how much money software vendors lost last year to illegal copying of programs according to ADAPSO (Association of Data Processing Services Organization), a computer-industry group representing software and service firms. ADAPSO, based in Arlington, VA, is sponsoring a lock-and-key system standard for computers to prevent illegal duplication of programs. The device connects to a computer's RS-232C port and limits use of duly protected software to the specific computer for which it was bought. Although negative consumer reaction has discouraged widespread endorsement by software firms, ADAPSO continues to push for adoption of the device, which it says costs about $25.

Nanobytes

NEC Electronics Inc. of Mountain View, CA, has introduced a 64K by 4-bit (256K) DRAM with an access time of 100 nanoseconds. The page-mode organization of the μPD41464 chip can help in designing memory in small segments: 64K bytes can be constructed of two chips instead of the eight required with standard 64K by 1-bit chips. . . . The **Massachusetts Microelectronic Center** is a $48 million educational center funded by high-technology industry and the Massachusetts state government. It will provide advance training and research opportunities in microelectronics and semiconductor technologies for students, scientists, and engineers. . . . **Symbolic Control** of Palo Alto, CA, has developed the 4thCPU-40 chip, which directly runs FORTH instructions at a rate of 8 million per second. Designed in 2-micron CMOS and sitting inside a 68-pin PLCC (plastic leaded chip carrier), the 4thCPU-40 can directly access 12 gigabytes and has a 20-MHz DMA coprocessor interface. In volume, the chip costs approximately $70. . . . **Western Union** has announced a new convenience for subscribers to its EasyLink on-line information service that lets users create and distribute customized business forms electronically via computer. The $100 package is called Instant Forms Plus. . . . **Advanced Micro Devices** of Sunnyvale, CA, has aimed its new Am2130 dual-port 8K static RAM at multiprocessor systems that need independent read/write access to a single memory. The 48-pin chip has separate I/O ports, addresses, and controls to let two devices read or write to memory at the same time. The 70-nanosecond version costs $44.80. . . . **Lotus Development Corporation** of Cambridge, MA, and **Living Videotext** of Mountain View, CA, have separately announced agreements with **Microsoft** of Bellevue, WA. Both companies will be developing applications that support the Microsoft Windows environment. . . . **Oki Semiconductor** of Sunnyvale, CA, is offering fast CMOS versions of the 8086 and 8088 microprocessors. The MSM80C86-2 and MSM80C88-2 run at 8 MHz, have a maximum power consumption of 275 milliwatts, and cost $20 in lots of 100. . . . Computer-terminal manufacturer **Wyse Technology** of San Jose, CA, announced plans to buy **Amdek Corporation**, the Chicago-based computer-monitor manufacturer. The acquisition involves about 650,000 shares of Wyse stock and is subject to approval by Amdek shareholders.

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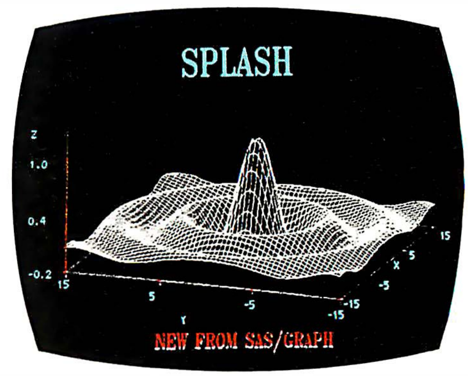
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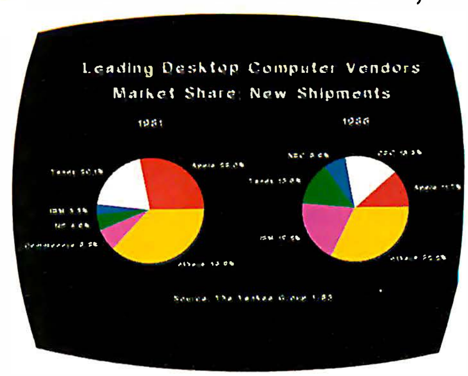


Compatibility with the IBM® Professional Graphics Adapter Board

didn't know which way to look.

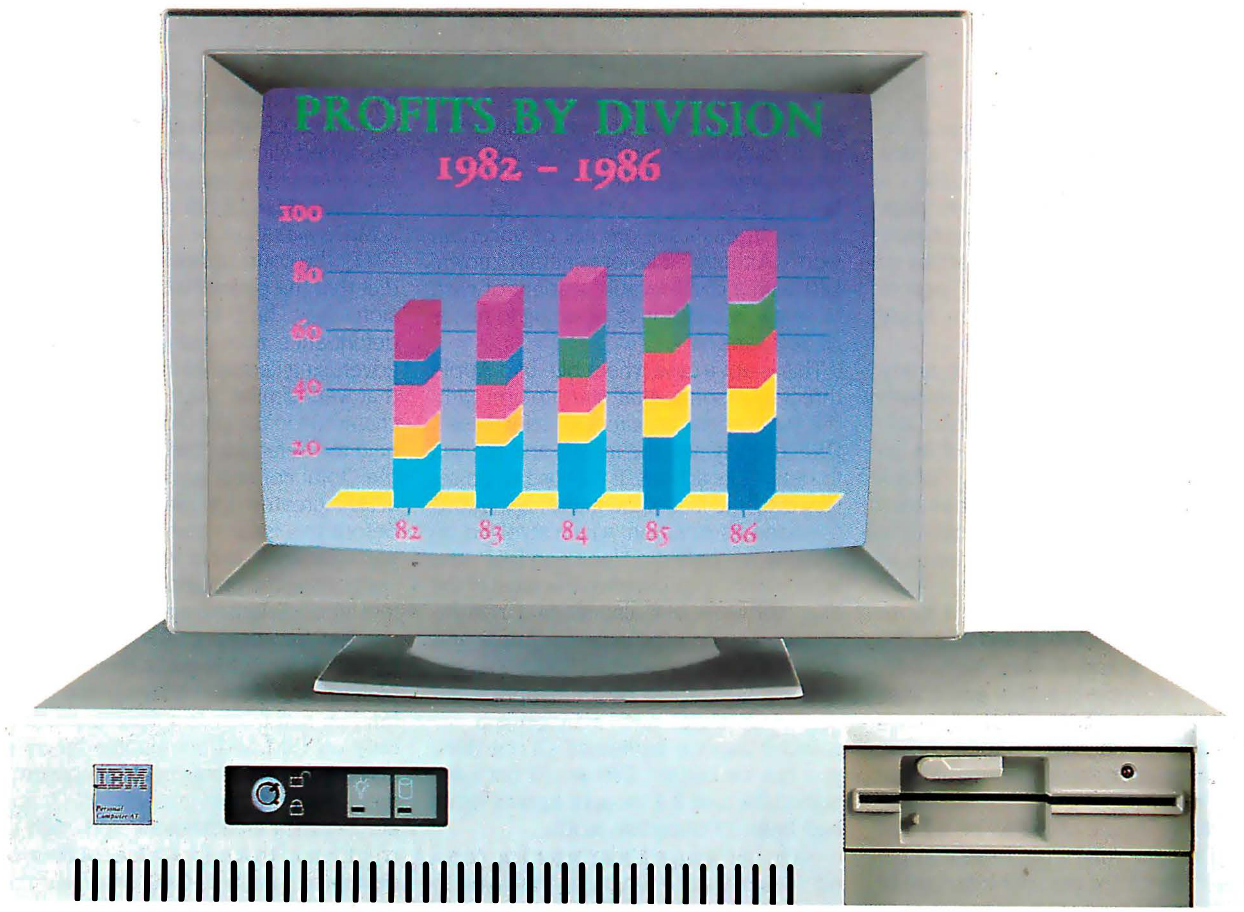
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Inquiry 238

VISUAL COPYRIGHTS

I applaud Gregg Williams's editorial regarding Apple's unconscionable action against Digital Research Inc. for GEM ("A Threat to Future Software," January, page 6). We at Batteries Included, a software publisher producing GEM applications on both the IBM PC and the Atari ST, experienced considerable dismay when Apple flexed its corporate legal muscle.

Unfortunately for the entire industry, Apple decided to pick on the company least able to defend itself. For its part, DRI clearly chose discretion over valor in acquiescing to Apple's pressure. What's most ironic is that GEM's most awkward feature, menus that drop automatically, was almost certainly originally created to avoid Apple's wrath.

At the time of the "settlement," I spoke with folks at both Microsoft and Atari. The former, when asked if they were concerned about Apple possibly going after them for Windows, simply laughed. Atari's comment was that they hoped Apple would come after them, they could use the free publicity.

Regrettably, Apple chose to be a bully. Can you imagine AT&T's response if Apple had gone after it for the user interface of the UNIX PC?

Your editorial stance is to be commended. Rarely do mass-market journals have the gumption to take a principled position against an advertiser. Apple deserves the ire of the microcomputer community. Our common goal should be to foster the development of a user interface, not the divisiveness of nonconstructive legal harassment.

MICHAEL H. REICHMANN
Richmond Hill, Ontario, Canada

It was with some dismay that I read your January editorial. Perhaps the most frustrating part of this is that we seemingly both want the same thing for the industry but come out on opposite sides of each issue. I trust you will forgive the length of this letter, but I have a number of points to make that will inevitably take considerable space and time to read. I have also listed a number of legal citations in case you should care to conduct further research on this matter.

I must begin by taking exception to your comment regarding "the uncertain worth of a 'visual copyright.' " As an attorney whose practice is in the area of computer law, I can assure you that the rights involved in this issue are not of uncertain worth. Although it is not generally known, DRI paid a considerable amount of cash to Apple in addition to agreeing to revise its software.

This is not a case where big, bad Apple threatened some small start-up firm without the financial resources to defend itself. DRI certainly had the means and the will to defend its actions, if it chose to do so. However, the fact of the matter is that DRI assessed its situation, which involved infringing not only the "look and feel" (the legal terminology covering this area) of the Mac software but also certain nondisclosure agreements between Apple and DRI and came to the conclusion that defending itself would be an inappropriate use of financial and management resources; thus the settlement. Of one thing you can be certain, DRI would not have settled the case if it thought Apple's rights had been of uncertain worth.

Some background here regarding copyright law would undoubtedly help you in understanding the situation. The copyright law protects computer programs in both source- and object-code forms [17 U.S.C. §§ 101,117] and declares anyone who violates the exclusive rights of the copyright holder to be an infringer of the copyright [17 U.S.C. §501(a)].

Further, the copyright laws grant the copyright owner the exclusive right to reproduce the work, to prepare derivative works based upon the copyrighted work, and to distribute the work [17 U.S.C. §106]. A work done for hire is protected for 75 years [17 U.S.C. §302].

The question that arose when the courts unequivocally upheld the rights of copyright owners in source and object codes and application and operating-system software was what would be the scope of protection for both the look and feel of the protected software.

In order to place this protection into context, you must remember that copyright law originally evolved to protect the works of authors in their writings (which included painters in their paintings). This protection of written and visual work was expanded with the advent of movies and, subsequently, television.

In *Sid & Marty Krofft Television Products Inc. v. McDonald's Corp.* 562 F.2d 1157 (9th Cir. 1977), the court upheld a lower-court verdict that the plaintiff's copyrighted television show had been infringed by the defendant's advertising campaign. This advertising campaign included characters that were similar, but not identical, to the characters in the plaintiff's show. The court held the defendant had infringed by using the "total concept and feel" of the characters created by plaintiff. Thus, even before this issue came to the fore in the software area, there was good case law supporting the protection of the look and feel in copyrighted material.

In *SAS Institute Inc. v. S&H Computer Systems Inc.* 605 F. Supp. 816 (M.D. Tenn. 1985), the plaintiff brought suit alleging that the defendant had taken its software, which ran only on IBM and compatible hardware, and infringed its copyright by converting the software to run under the VAX operating-system environment. Although the court found that only 44 lines of code out of approximately 180,000 had been plagiarized from the SAS code, it found substantial modular similarity and a copying of the user-interface dialogue. In finding for the plaintiff, the court held that there had been an "extensive taking of the structure and topical sequence" of the SAS software.

In *Whelan Associates Inc. v. Jaslow Dental Laboratory Inc.* 609 F. Supp. 1307 (E. D. Penn. 1985), the court held that "the 'expression of an idea' in a software program is the

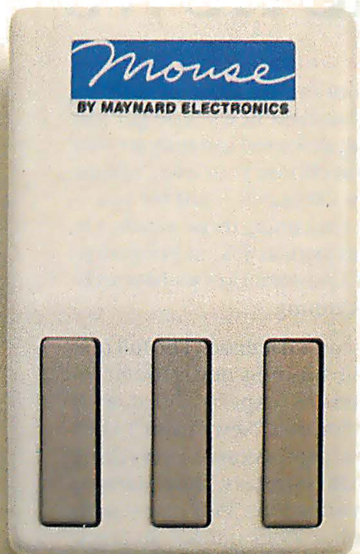
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Adjustable Cursor Speed/Rt, Lft (while running application)	Yes	No	No
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manner in which the program operates, controls and regulates the computer in receiving, assembling, calculating, retaining, correlating, and producing useful information either on a screen, printout, or by audio communication." The court continued in stating that "the expression of the idea embodied in the computer program is protected by the copyright laws. . . ." On the basis of substantial similarity, the court found infringement on the part of the defendant.

In essence, what the courts are saying is that copyright in software extends beyond the code itself and also includes the organization and user dialogue, i.e., the look and feel. While this viewpoint might seem revolutionary to laymen or even attorneys who are unfamiliar with intellectual-property law, it is not a broad, new interpretation of the copyright law.

For instance, the copying of the internal structure and organization of a textbook (the table of contents) has been held to be an infringement of the copyrighted work (*Meredith Corp. v. Harper & Row Publishers Inc.* 500 F. 2d 1221 (2d Cir. 1974)). And, in *Roth Greeting Cards v. United Card Co.* 429 F. 2d 1106 (9th Cir. 1970), the court held the sale of greeting cards that copied the total concept and feel of the plaintiff's copyrighted cards to be an infringement. Given this background, the protection of the look and feel in software is in compliance with long-held case law.

I feel compelled to add, lest you adopt the somewhat unique argument of the current U.S. Attorney General regarding case decisions that go beyond the intent of the legislators who drafted the laws, that Congress made two substantial revisions to the copyright laws, in 1976 and 1980. If Congress had felt that the courts' rulings in *Harper & Row* and *Roth* were a misapplication of the law, there was more than ample opportunity to correct the problem in the 1976 and 1980 revisions. That Congress did not revise the copyright laws to overrule the courts' decisions is a definite indication that it did not see any problem with the rulings.

Although the legal analysis of the courts in *SAS* and *Jaslow* is based upon interpretation of the copyright laws, the underlying rationale is really based upon ethical and economic arguments.

In both *Jaslow* and *SAS* the infringing defendants took software that had been successful in one operating environment (IBM Series/1 and IBM mainframes, respectively) and made clones operating under another environment (IBM PC and

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DEC VAX, respectively). Was this done from some altruistic sense of providing computing power to the people? Of course not; it was done to make money.

These programs were not selected at random. The defendants selected these programs because they had proved successful in their initial operating environments. So, what the defendants decided to do was to take the successful, creative work of the authors and then port it to another environment in order to make themselves money.

The truth of the matter is that programming per se is not a creative act. The creative act is in the design and organization of the software. And, when we look at the marketplace, the ease of operation by the user is a considerable factor in whether the design and organization of a software product is successful. (If you doubt this, ask yourself if WordStar would be a success or a flop if initially released today.)

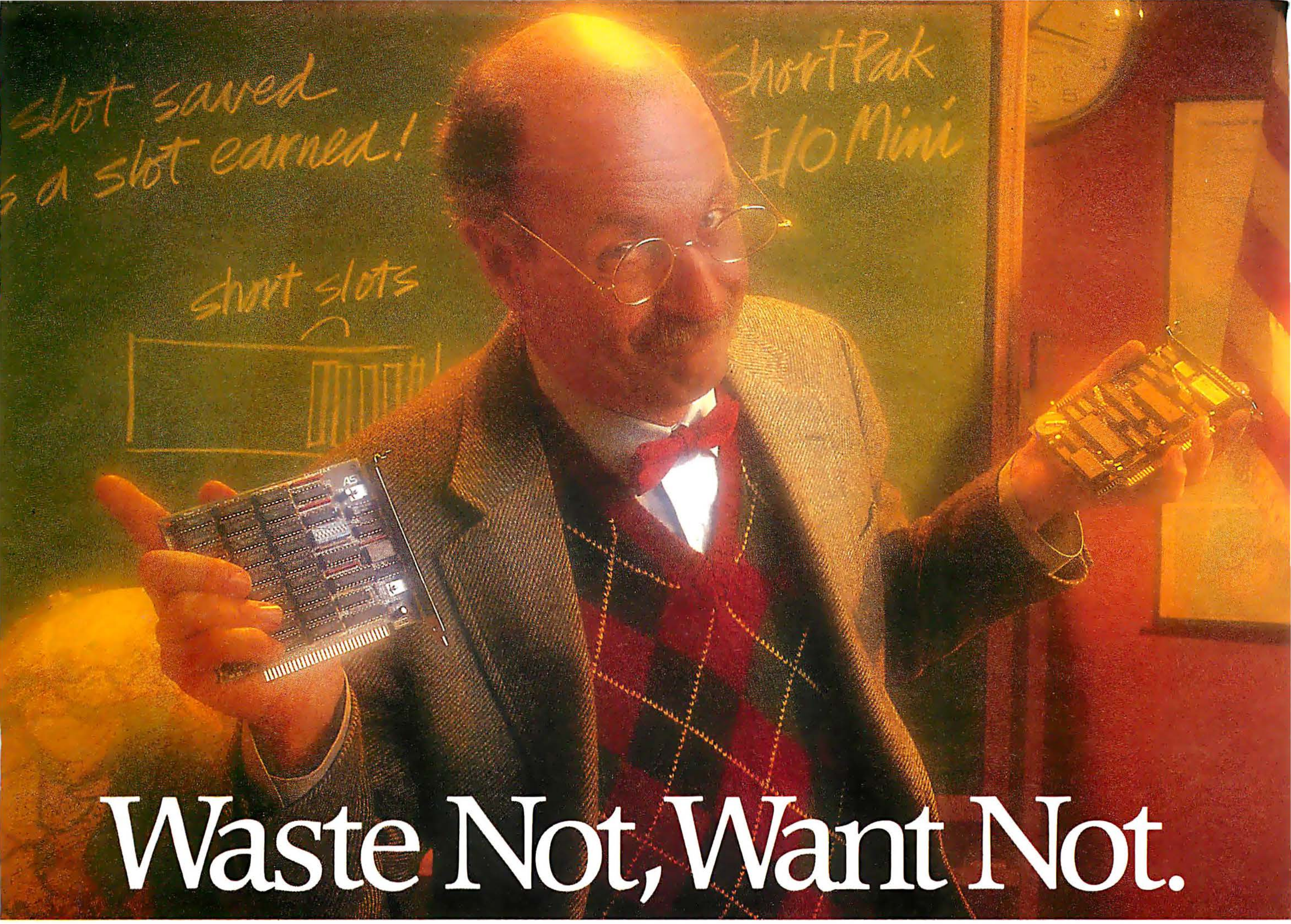
To put it bluntly, what the defendants in *Whelan*, *SAS*, and *DRI* did was to rip off a successful look and feel from its rightful author. Once you have that, the coding is merely grunt work.

What the courts are really saying in these cases is that to deprive the authors of the fruits of their creative efforts is unethical and that it won't be tolerated in American commerce. It will be a very sad time indeed, Mr. Williams, if the standard of business in this country becomes such that it is considered unethical to deprive the rip-off artists of their "right" to pirate someone else's creativity.

Your argument regarding standardization in the computer industry is fine as far as it goes. But it misses the point regarding how a standard is attained. Standards don't become standards merely because the issuing party says that this is now the standard. Alas, there are some notable failures attempting to do just that in the not too distant past. Standards become standards because the publisher wants it to become a standard *and* the public (users in this context) decide that something is useful to them, and it becomes the standard by popular election.

However, carrying your argument to its logical conclusion would make the public's (or some portion thereof) desire to make some piece of software a standard amount to a taking of the intellectual property inherent in the software by eminent domain, with the compensation to the developer for such condemnation being an increase in revenues from some other

(continued)



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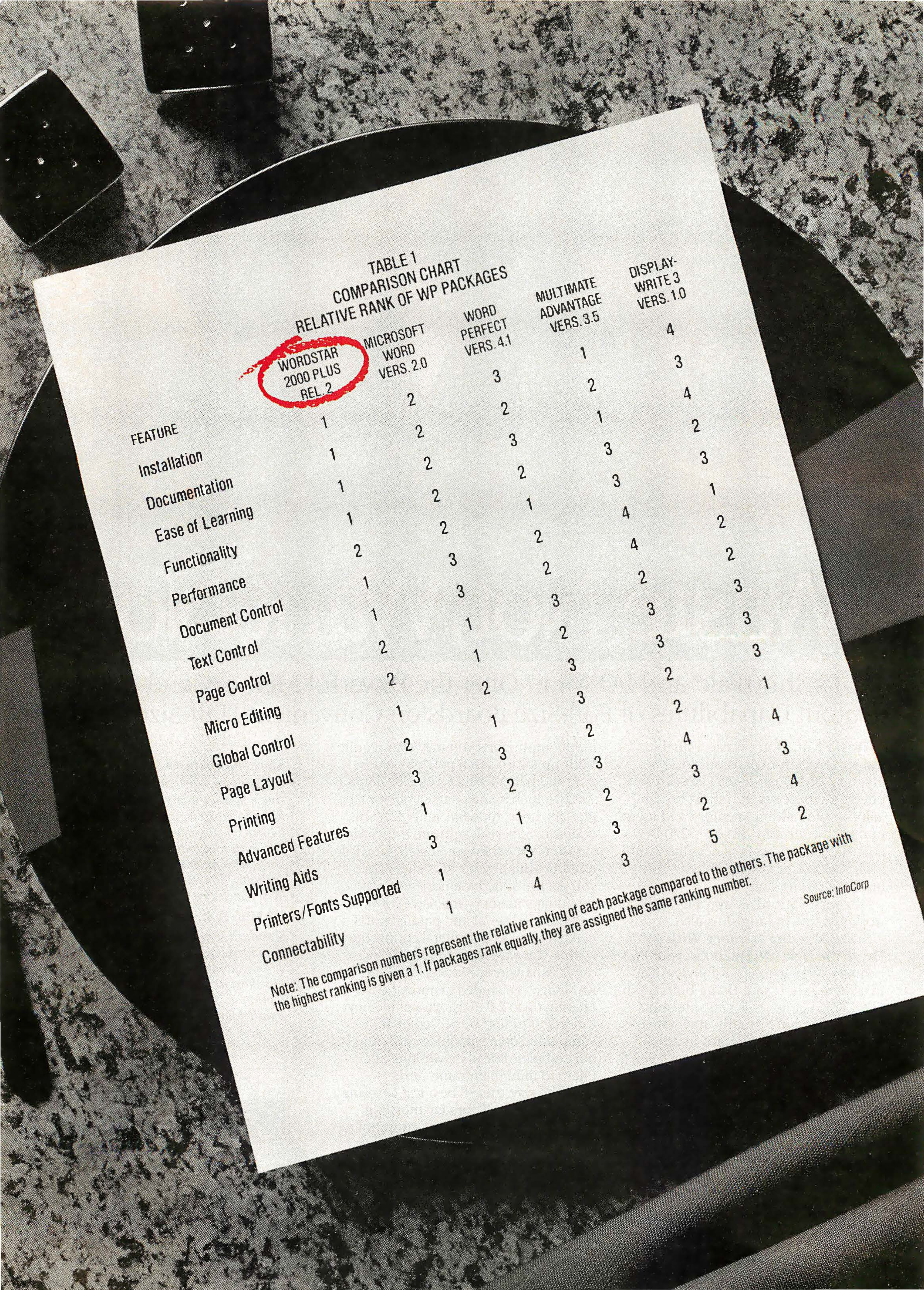


TABLE 1
COMPARISON CHART
RELATIVE RANK OF WP PACKAGES

FEATURE	WORDSTAR 2000 PLUS REL. 2	MICROSOFT WORD VERS. 2.0	WORD PERFECT VERS. 4.1	MULTIMATE ADVANTAGE VERS. 3.5	DISPLAY-WRITE 3 VERS. 1.0
Installation	1	2	3	1	4
Documentation	1	2	2	2	3
Ease of Learning	1	2	3	1	4
Functionality	1	2	2	3	2
Performance	2	2	1	3	3
Document Control	1	3	2	4	1
Text Control	1	3	2	4	2
Page Control	2	1	3	2	2
Micro Editing	2	1	2	3	3
Global Control	1	2	3	3	3
Page Layout	2	1	3	2	3
Printing	3	3	2	2	1
Advanced Features	1	2	3	4	4
Writing Aids	3	1	2	3	3
Printers/Fonts Supported	1	3	3	2	4
Connectability	1	4	3	5	2

Note: The comparison numbers represent the relative ranking of each package compared to the others. The package with the highest ranking is given a 1. If packages rank equally, they are assigned the same ranking number.

Source: InfoCorp



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portion of the business (in Apple's case, hardware).

The problem arises when the author of the so-called standard doesn't want it to become the standard, as is the case with Apple and the Mac software look and feel. In this case the desire of the public (assuming it exists in this matter) must take a back seat to the rights of the author. It is the author's privilege to make the use he or she sees fit of such personal-property rights.

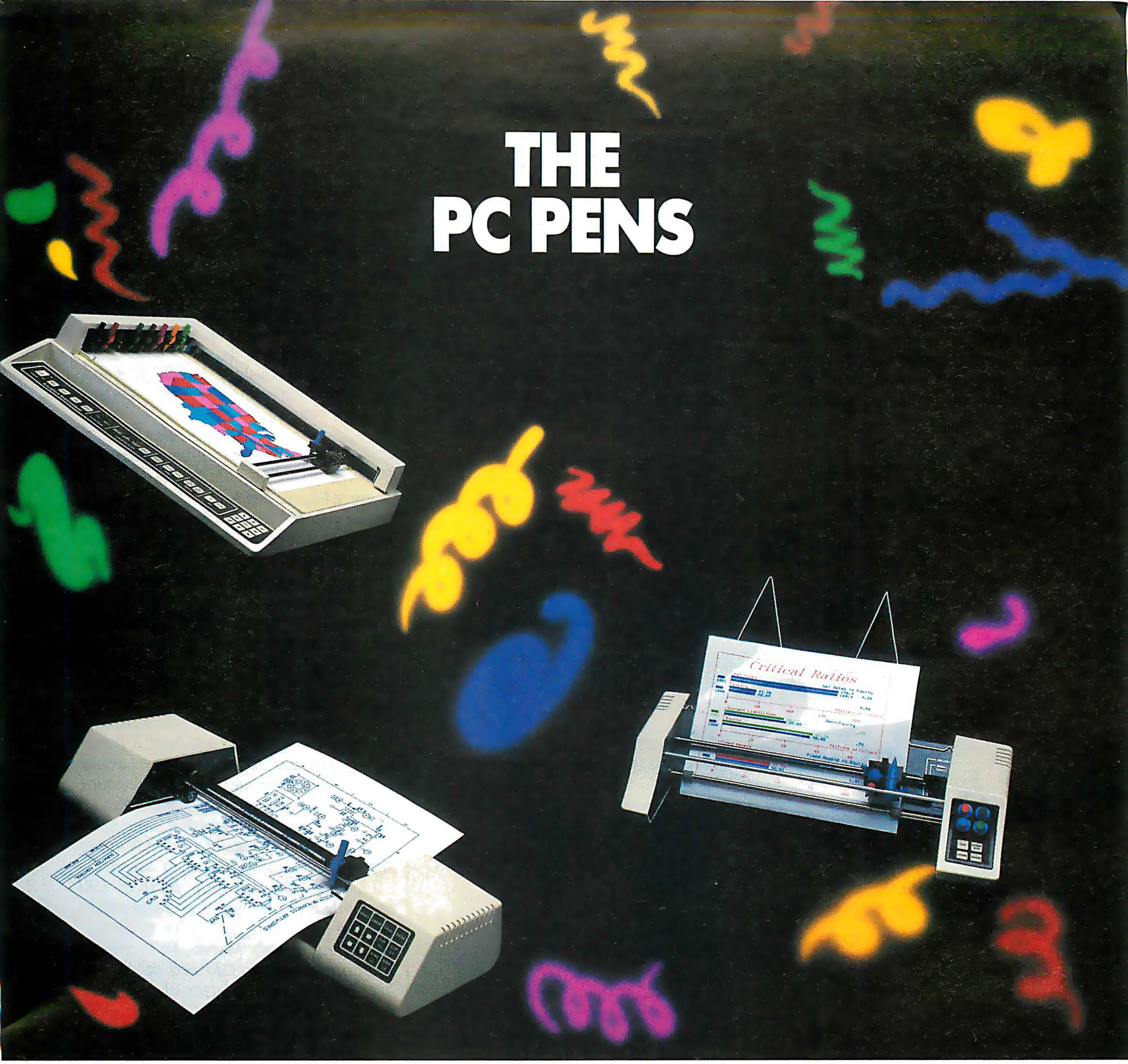
Finally, I believe that your economic analysis of this situation is in error. If you look at the entire history of software development, you find that improvements, particularly in the user interface/dialogue, came from having to compete in the marketplace. In the late sixties and early seventies, the little interactive mainframe software in existence was decidedly user-unfriendly. Then along came the minis, and software written for them was much more user-friendly (although crude by today's standards), and suddenly, mainframe software, both commercial packages and in-house developed, went through substantial revisions in order to meet the new expectations of what the user interface/dialogue was supposed to be.

In the late seventies and early eighties came the micro revolution. How did the software authors compete in the office environment against much more powerful hardware/software combinations? They made the software even more user-friendly. Thus accountants, financial analysts, attorneys, and middle managers began to bring computing power to their own desks instead of relying upon data-processing professionals with their rules, regulations, buzzwords, and priorities. It can fairly be said that the dawn of user-friendly micro software ended the monolithic power structure of the data-processing organizations in business.

This user-friendly environment has created its own synergy in the industry. In the same manner that sophisticated mini software forced change upon new and existing mainframe software, now the micro software has forced change upon new and existing mini and mainframe software. With the advent of such packages as Symphony and Framework heralding the beginning of very sophisticated, integrated packages, this trend will continue into the foreseeable future. Or will it?

I believe that, if your arguments are followed, it will not. The reason is that it will not make economic sense for software developers to expend vast amounts of

(continued)



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resources—time, effort, and money—to create the extensive user-friendly interface/dialogue necessary to make these systems work efficiently, if the result of that work cannot be protected. Allowing the look and feel of software to be co-opted by anyone who feels like it will be a universal disincentive to software developers.

The marketplace will become stagnant because the price for success will be imitation by other software developers, with the resulting loss of uniqueness and revenue. It is only by securing the authors' absolute right to exploit the economic advantage made possible by their creations, that the present trends in software development will continue.

It wasn't that long ago—May 1981—when BYTE devoted a whole issue to software protection. At that time, you took a stand that needed to be taken and, perhaps more importantly, raised the consciousness of many people regarding the ethics of illicit copying of software. Thus my dismay at reading your editorial. While the issues are somewhat more subtle, the principles are the same.

I can only hope that this letter may cause you to reconsider your editorial and return the BYTE philosophy to whence it came in 1981.

JAMES E. BRANSFIELD
Toluca Lake, CA

Gregg Williams replies:
Thank you for your authoritative letter, which includes one case I had heard of and several that I had not. I think you've clearly indicated the legal context that supports the idea of "visual copyrights."

Despite the legal defensibility of the "visual copyright" concept, my opinion concerning it remains (as it was in the editorial) threefold. First, I think that, even though the concept is legal, perhaps its legality should be reconsidered; in my opinion, its use will have a harmful effect on the industry. Second, I would rather see Apple vindicate the concept in court instead of pressuring a company to settle. Third, I maintain that, even if this concept remains legally valid, it is not in Apple's long-term interest to use it.

I have to disagree with you that "DRI certainly had the means and the will to defend its actions, if it chose to do so." According to Judy Mervis, DRI's public-relations manager, DRI laid off "about 100 people, or a quarter of our workforce, worldwide" in mid-July 1985, which is exactly the time at which Apple was negotiating the settlement (which was finalized September 30) with them. I'd guess that DRI was financially strapped at the time and could not afford a legal battle.

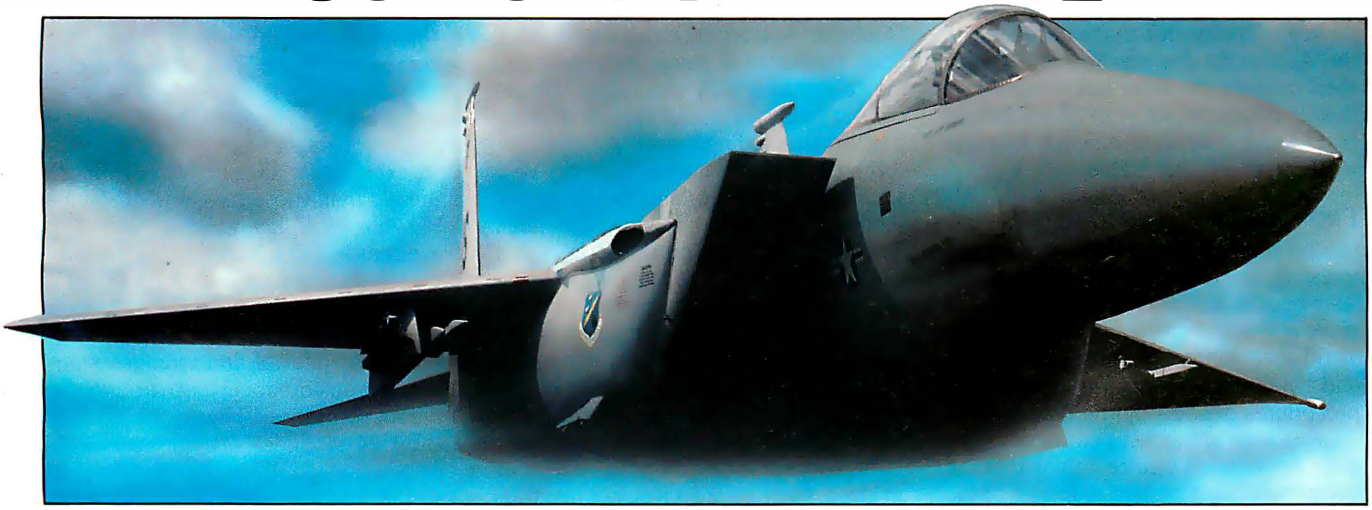
Another factor that forced DRI to acquiesce was its fear that Apple could get an injunction that would prohibit it from selling its GEM products until the case was settled (which would take years). According to Ms. Mervis, DRI couldn't afford to put GEM, one of its major income-producing products, into "suspended animation." "It wasn't just the money [that we couldn't afford]," she said, "but, most of all, the time. There's a window of opportunity for GEM, and it's now, not two years from now."

Finally, I have to restate my belief that Apple's self-protective actions will, in fact, stunt the growth of the microcomputer

(continued)

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THE F-15 JET FIGHTER. IF THE COMPUTER GOES DOWN SO DOES THE PLANE



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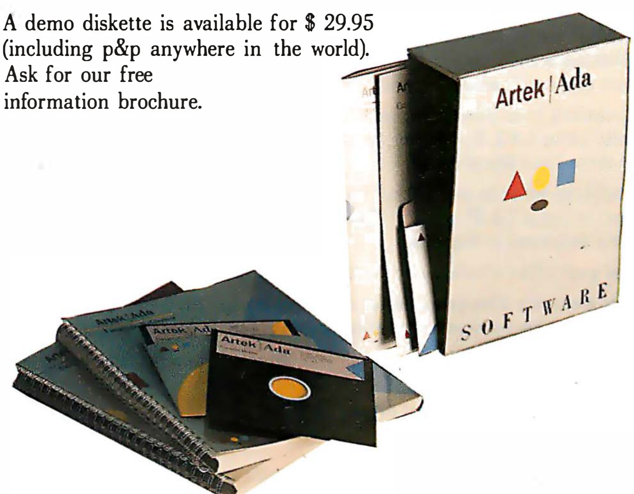
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Inquiry 24

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industry and cause the company to lose even more of its market share to the IBM world. Software protection—actually, software piracy—is a separate issue that BYTE disapproved of in 1981 and disapproves of today, but that's unrelated to the Apple/DRI dispute. You and I must then present the facts but disagree on their implications; we at BYTE still believe that Apple's actions against DRI are neither fair nor advisable.

From Insects to Robotics

I found your January issue on Robotics interesting. The cover was super! Sooner or later people will teach machines how to move and accomplish objectives in a real-world environment. The question is, When and by what paths will we discover the procedures needed by the machines?

I would like to suggest a path that at first glance may seem bizarre. I think that the complete dissection and mapping of the nervous system of an insect (via the electron microscope) will provide us with the necessary procedures. Why do I say this? Simply because these creatures exist and thrive in a real-world environment and they do this by processing information about the world in biological time (nervous-system interaction), which is a good deal slower than digital. Reading "Multiple Robotic Manipulators" by J. Scott Hawker et al. (page 203) reminded me of watching a fly clean itself. So the code already exists, in flies and other creatures, including man.

There are many insects that are very small. True, they are large in the microscopic sense, but other, larger creatures are for all practical purposes infinite. I think that the complete mapping of an insect's nervous system is possible. Without question we will discover inputs that we don't understand, but all we will need to know is how the input interfaces to the system. The input's influence on the system can then be derived.

This concept is based on the belief that an insect's actions are a result of nervous-system (hardware) processing of sensory input. It is my guess that the map could be produced by three people in two years. There may be a very simple reason that invalidates this concept, but I have yet to hear it.

Robert Hester
Toulouse, France

ZBasic Benchmark

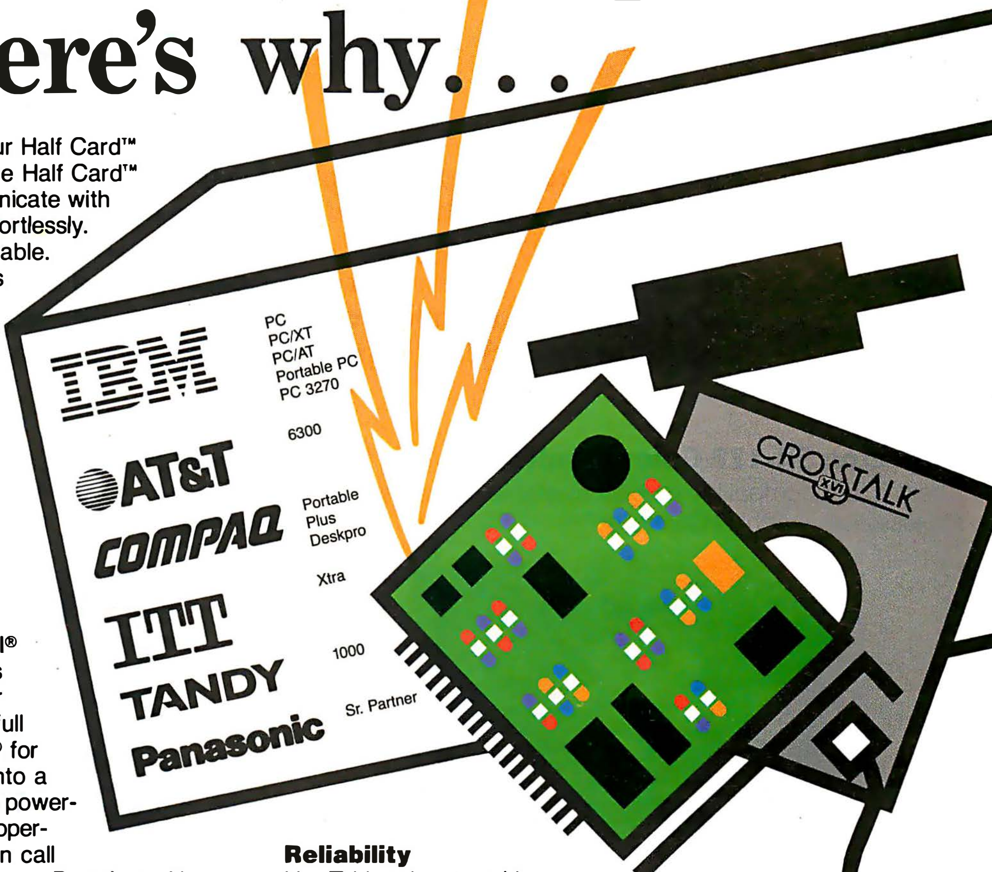
After reading Bruce Webster's comments on benchmarking ("According to Webster: Benchmarking," January, page 371), I thought you might be interested in my recent experience, an example even more dramatic than those he gave.

I have a Plain Jane Morrow MD3. The Sieve runs in 152 seconds using the bundled MBASIC, or it can run in 2.4 seconds using ZBasic just purchased from Zedcor. To get a reasonably accurate measure of that short an interval, and without system time, I put an additional loop around the program so it does 10 iterations. It takes a short 24 seconds.

Another way to dramatize the difference is to put in a print statement. That slows ZBasic down to 21 seconds. With MBASIC, 21 seconds is the same time it takes for the first integer, 3, to print. Printing only

(continued)

Ven-Tel's Half Card™ modem is in all the best computers. Here's why...



Ven-Tel gives you lots of reasons to buy our Half Card™ modem for your IBM PC or compatible. The Half Card™ is a complete system that lets you communicate with other PCs, mainframes, and databases effortlessly. It includes Crosstalk-XVI® software. It's reliable. It's got all of the features you want. And it's a good value.

Do You Own One of These Computers?

Chances are you do. And if you're thinking of buying a modem, consider the Half Card™. Because of its small size, the Half Card™ fits in more computers, including all of the models we've listed here. The Half Card™ is small, so it fits in short slots or long. That means you can save your long slots for other expansion uses.

Effortless Communication

Each Half Card™ comes with Crosstalk-XVI® communications software, by Microstuf. It's the easiest to use, whether you're a beginner or an old hand, and the most powerful. A full on-line help menu makes using Crosstalk® for the first time a snap. It can turn your PC into a terminal on a mainframe computer with its powerful terminal emulation feature. It will even operate your PC when you're not there. You can call into an information service such as The Source or Dow Jones News Retrieval, or transfer files and electronic mail, all at the touch of a button. The Half Card™ connects your computer to the world. Effortlessly.

More Modem for Your Money

When you buy the Half Card,™ you don't need anything else. The Half Card™ is a complete communications package that includes a full-featured modem and the best known software on the market. Complete easy-to-understand instructions with full technical support on installation and use. And a very competitive price. The Half Card,™ with Crosstalk-XVI® software, retails for only $549.

Reliability

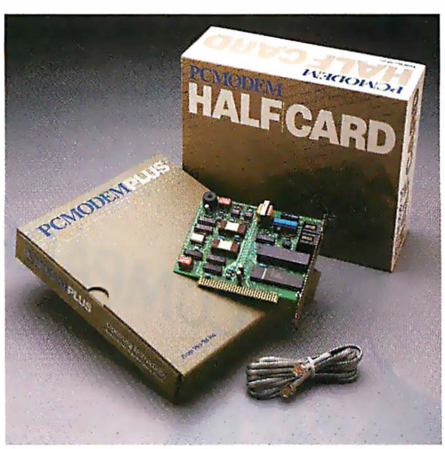
Ven-Tel has been making modems for 10 years. Our experience shows. Ven-Tel's Half Card™ only has about 70 parts, compared to almost 300 on other modems. We reduced the parts by building the first LSI modem chip using advanced switched capacitor technology. What that means to you is greater reliability and lower power consumption, so you can load up your PC with expansion boards and not worry about heat or power problems. And we back the Half Card™ with a full two-year warranty on parts and labor.

You Can Buy the Half Card™ Anywhere

You can get the Half Card™ at ComputerLand, Businessland, the Genra Group, Entré Computer Centers, Macy's Computer Stores and other fine dealers nationwide. Also from Ven-Tel: the 1200 Plus,™ an external modem and the PC Modem 1200,™ an IBM internal with V.22 international capability.

Features

- 1200/300 baud auto-dial, auto-answer.
- Uses the industry standard "AT" command set.
- Runs with virtually all communications software, including Smartcom II and PC Talk *III* and integrated packages such as Symphony and Framework.
- Includes Crosstalk-XVI® software.
- On-board speaker and extra phone jack for easy switching from voice to data mode.
- Selective tone or pulse dialing; full or half duplex.
- Automatic answer on any ring.
- True ring or busy signal detection.



Effortless Communication

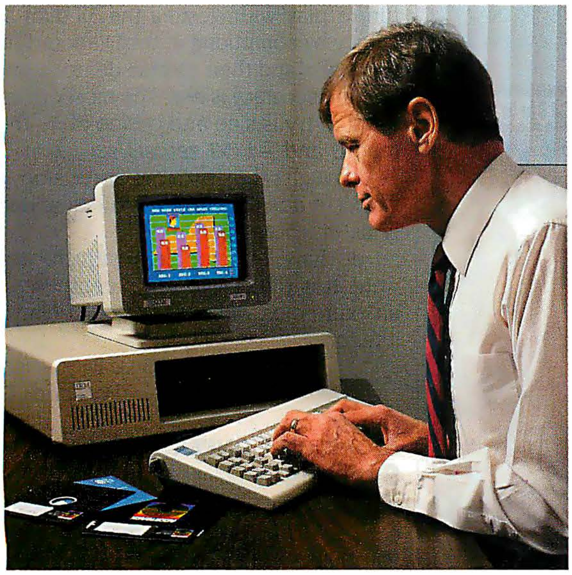
Ven-Tel Inc.

2342 Walsh Avenue
Santa Clara, CA 95051
(408) 727-5721

Crosstalk is a registered trademark of Microstuf, Inc. Smartcom II is a trademark of Hayes Microcomputer Products. Symphony is a trademark of Lotus Development. Framework is a trademark of Ashton-Tate.

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Princeton HX-9 Series
For more performance in less space, the Princeton HX-9 series is in a class by itself.



Nobody else—not even IBM—offers a 9", high-resolution RGB color display. The HX-9 and HX-9E feature a super-sharp .28mm dot pitch tube for crisp, clear text and graphics. Nonglare screens for less eye strain. The built-in tilt-and-swivel base allows you to adjust the screen to a comfortable viewing angle. Select green or amber display modes with built-in green/amber switch.

Full IBM compatibility enables you to use the HX-9 or HX-9E with the IBM Color Graphics Adapter.* The HX-9E gives you added flexibility of full compatibility with the IBM Enhanced Graphics Adapter.*

Our other monitors also give you full IBM compatibility:

Princeton SR-12 Color Monitor—boasts twice the vertical resolution of the IBM Color Display... when used with graphics adapter cards such as the Sigma Designs Color 400.

Princeton MAX-12 Amber Monochrome Monitor—ergonomically designed to give you up to 15** shades of high-resolution amber... plus high-resolution text and graphics when used with a monochrome card.



1984 and 1985 winner of the PC World "World Class PC Competition"!

Princeton HX-12 Color Monitor—16 sharp, clear colors and superb character definition make the HX-12 the winning choice among monitor users...



Princeton HX-12



IBM 5153

COMPARE:	**Princeton HX-12**	**IBM 5153**
Dot Pitch	**.31 mm**	**.43 mm**
Nonglare Screen	**Yes**	**No**
Warranty	**1 Year**	**90 Days**

See the clearly superior Princeton Monitors at your Authorized Princeton Graphic Systems Dealer. For the dealer nearest you, please call: **800-221-1490 (Extension 1604)**, 609-683-1660 (NJ only), Telex: 821402 PGS PRIN.

Princeton Graphic Systems, 601 Ewing Street, Bldg. A, Princeton, NJ 08540.

* Or equivalents.
** When used with IBM Color Graphics Adapter or equivalent.
IBM is a registered trademark of International Business Machines Corporation.
Sigma Designs Color 400 is a registered trademark of Sigma Designs, Inc.

PRINCETON™
GRAPHIC SYSTEMS
AN INTELLIGENT SYSTEMS COMPANY

Inquiry 264



slows MBASIC down by 10 seconds to 162.

The real reason for getting ZBasic was my frustration with only single precision for MBASIC functions. To get added precision with the MBASIC compiler was $400. ZBasic was $90. Not only is it fast, it is precise. It can be configured for from 2 to 54 digits of accuracy. Certainly there is no need here for that accuracy, but since this is a hobby, too, it's nice to have and fun to play with. Testing the 54-digit accuracy by computing π, then various functions of π and their inverse demonstrates that the accuracy is real. The most obvious thing to try is sine and cosine of π. They read 0 and −1.(52 zeros)3.

Although the extreme precision is slower, it does not increase run time nearly as much as expected.

I do have one problem with the software. It is difficult to use parentheses in an expression without the result being an integer.

BILL E. JOHNSON
Portland, OR

MORE ON CONFERENCING SYSTEMS

Your December 1985 theme signaled the coming of age of a new industry, which you called "computer conferencing." That phrase tends to underestimate powerful "electronic organization" and pervasive "electronic culture" that are already making "electronic mail" and "computer conferencing" seem like relics. Some day, using 20/20 hindsight, we will see the eighties as this industry's horseless-carriage stage.

E-mail gave us distance independence and time independence. Electronic bulletin boards moved us from one-to-one to topic-oriented, one-to-many communication. Early computer conferencing gave us dynamic user records that allowed few-to-few communication within relatively fixed conferences. Such systems kept track, by each participant, of what had been read versus what was new in that particular topic. Many-to-many communication did not appear until this decade's introduction of topic branching to allow "many"—meaning thousands—to easily and spontaneously form separate interest groups. Computer conferencing today allows networking in human terms on an unprecedented scale.

The most advanced conferencing software now adds sufficient access controls to topic branching to be able to be molded to various organizations. These

(continued)

PC Paintbrush.™
Because life is too short for monochrome pie charts.

Fun is the best thing to have.

With PC Paintbrush, you can add color, flair, dimension and creativity to a chart, a presentation, or an otherwise dull day. From charts and graphs to serious computer art, our newest generation 3.0 PC Paintbrush will cheer you on with features no other graphics package can match.

Best of all, it's easy to use. You don't have to learn up to sixty commands, like you do with some products. If you can understand icons as simple as scissors, paintbrush, spray can and paint roller, you're ready to start using PC Paintbrush.

The pen is mightier than the keyboard.

None of history's great artists drew with a keyboard, and you shouldn't have to either. So PC Paintbrush is now available with a Summasketch MM™ Series drawing tablet, to give you complete freedom of expression. Of course, it also supports regular mice, joysticks, graphics tablets, and is compatible with most graphics cards.

PC Paintbrush also has a beautiful way with words. The text icon lets you write in any of eleven fonts, in nine sizes, with italics, outline, shadow and boldface variations.

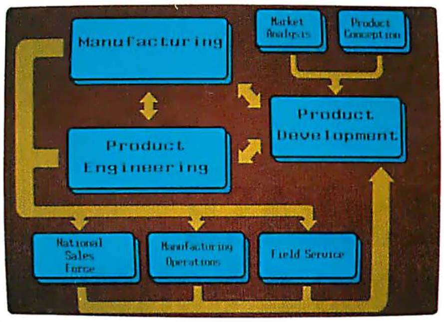
What's more, with the new 3.0 PC Paintbrush, you can draw rounded boxes, rubber band curves and circles, and edit pictures many times larger than the screen.

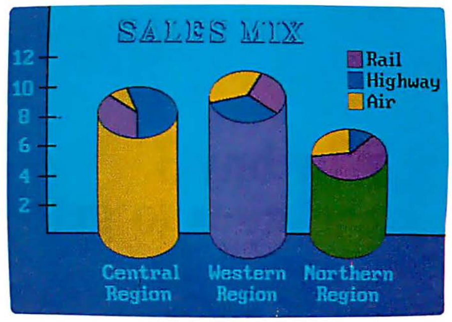
Are we making fun of 1-2-3®? Why not?

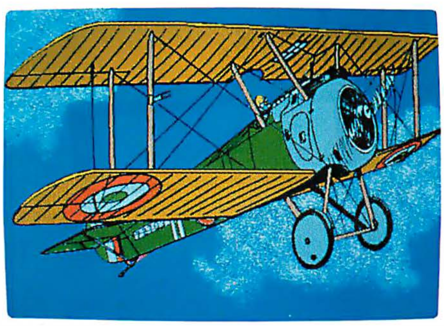
For Lotus™ users, PC Paintbrush's new PIC interpreter loads 1-2-3™ and Symphony™ charts and graphs at your equipment's best resolution, from an IBM EGA™ (640 X 350 X 16 colors) to a Number Nine Revolution™ (512 X 512 X 256 colors).

With our FRIEZE™ frame grabber you can pull graphics created by any program right off the screen into PC Paintbrush. So you can take your Paintbrush and pallette anywhere, improving the looks of things as you go. And having a lot of fun on the way. In addition, our optional slide show package, PC PRESENTATION, allows you to program your graphics into a first class presentation with fades, zooms, quick cuts and animation.

Go on, live a little.









PC Paintbrush supports 19 video graphics cards and 30 printers and plotters.

For more information on PC Paintbrush, call or write us at the address below, or ask your computer dealer for a demonstration.



Z-SOFT
PC Paintbrush

See us at COMDEX/Spring '86
April 28-May 1, 1986
Georgia World Congress Center
Atlanta, GA

Ask about our PC Paintbrush & Summasketch™ drawing tablet special

Corporate Headquarters:
ZSoft Corporation, 1950 Spectrum Circle, Suite A 495, Marietta, GA 30067, 404/980-1950

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systems can be configured so that they are no longer perceived by their users to be generic communication systems but rather as more specialized management tools. "Electronic organization" deals with how these systems are designed and used to address specific business problems. Business problems currently being solved via this medium include project coordination for the organization and implementation of plans, specifications, tasks, and subtasks; sales management for the tracking of leads, prospects, customers, and competitors; and customer service for the answering of inquiries, complaints, and suggestions.

"Electronic culture" deals with how electronic communication systems need to be organized in order to be integrated with more established forms of communication. Electronic communication systems must mirror the organizational culture or they have a high chance of failure.

Brock N. Meeks, in his article titled "An Overview of Conferencing Systems" (page 169), did not show how the fixed conference structures of the early days differ from "many-to-many communication" aspects introduced in the eighties or from concepts of "electronic organization" and "electronic culture," which could dominate the industry by the end of this decade. An even more serious lack for those using his article for systems assessment is that the article confused the roles and importance of software functionality, information content, and on-line culture associated with each implementation he reviewed.

For example, he described PARTICIPATE in terms of the public systems he has used. We are glad that individuals are being entertained and educated on these public systems. However, these public systems represent less than 10 percent of all PARTICIPATE installations. More important, the information content and the on-line cultures associated with the more numerous corporate installations of PARTICIPATE are as different as the number of installations we have. On-line cultural differences stem not only from differing purposes to which computer conferencing systems can be put but also from the information content of the business applications and from the existing communications culture of the organizations making use of the medium. This interplay of software functionality, information content, and culture was not made explicit by Mr. Meeks. Yet it is this complete picture that determines the success or failure of the medium.

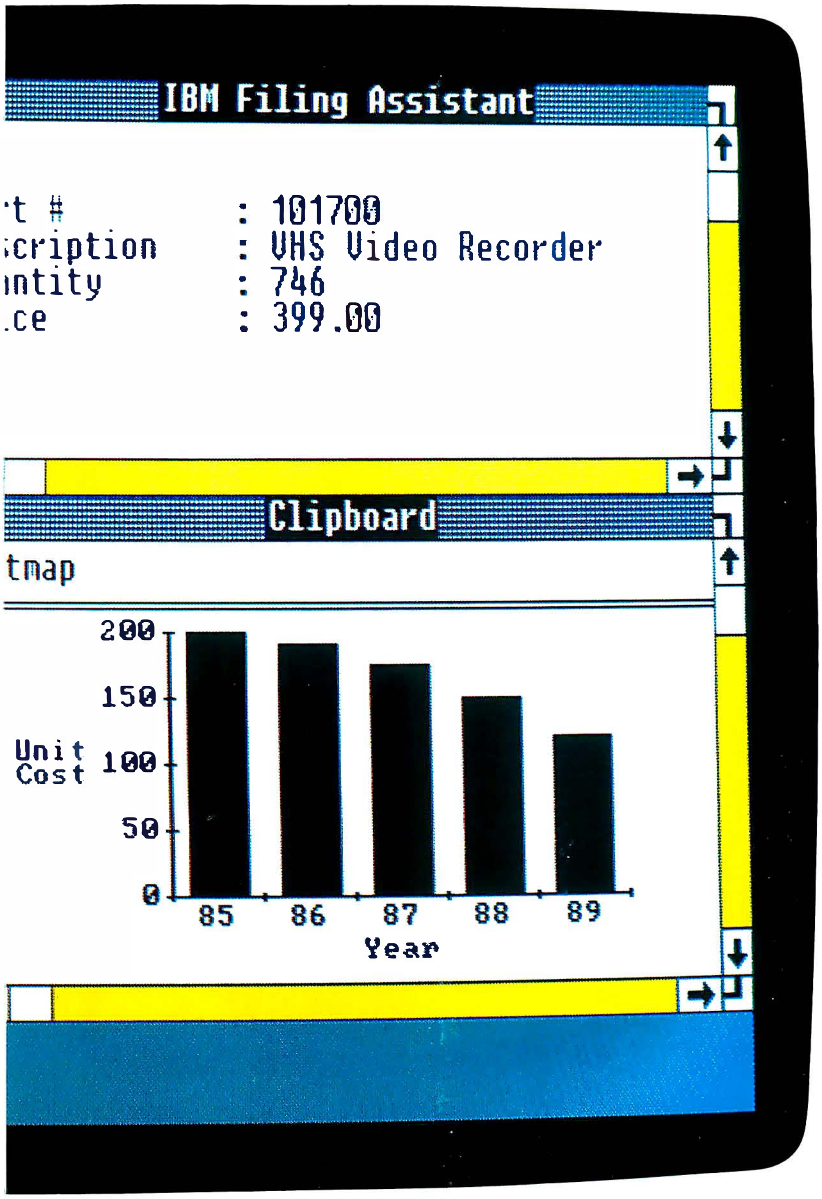
CHANDLER HARRISON STEVENS
Participation Systems Inc.
Winchester, MA

Congratulations for the extensive and well-written articles regarding computer conferencing (December 1985). Brock Meeks did a fine job of researching and reviewing the technology and many of the participants in this growing industry. As the creator of CONFER II, I appreciate having our product so favorably reviewed. I am especially pleased that BYTE was able to increase awareness of this communication and decision enhancing tool.

I would like to correct a few minor inaccuracies in Mr. Meeks's comments about CONFER II: (1) The product is actually registered as CONFER II, not CONFER, and is owned by Advertel Communication

(continued on page 340)

Microsoft Introduces Power Windows.



done for you.

Choose your best word processor, spreadsheet, database—you name it. They're all there for you at a keystroke.

Common ground.

Finally, Windows is not only an immensely powerful tool for today, it's also a solid base for a new generation of Windows applications.

As an introductory offer, two of these—Microsoft Windows Write and Paint—are included in the package. Along with more than a dozen other programs.

In Windows applications you have a common interface which includes drop-down menus, dialog boxes, icons. Along with a richer environment that allows you to mix pictures and text. And to summon different type faces and styles at a keystroke.

Windows is a bridge between today's applications and the graphics based software now evolving. A way to work interchangeably with today's programs. And tomorrow's.

If you're someone who uses personal computing as a natural part of your work life, who capitalizes on the productive powers of sophisticated applications, look into Windows, a new vision of what a computer can do.

Spreading knowledge.

Another great service Windows performs is accelerating the movement of information from one program to another.

Collecting and combining that information is as simple as taking a "snapshot" of data in one program. Editing it. Then consolidating it with data from other programs.

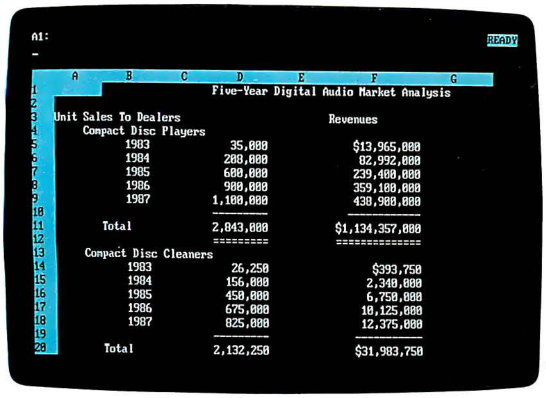
With Windows, you can enjoy the advantages of conventional integrated programs without their compromises. Because Windows lets you put together the applications that you know, and that get a job

Windows breaks down walls.

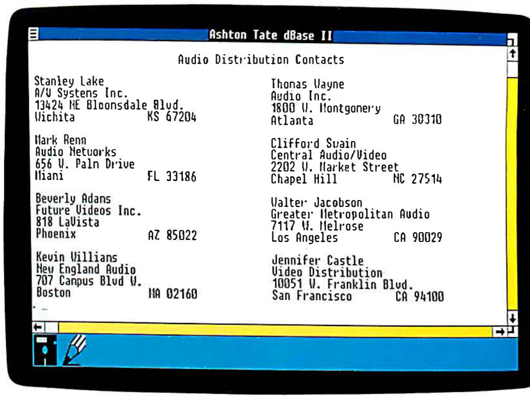
Windows lets you freely combine information from all your applications. And gives you the means to organize, compose, format and print it.

The staging areas for this consolidation are Windows Write and Windows Paint. Two graphics based programs which are bundled with the Windows package.

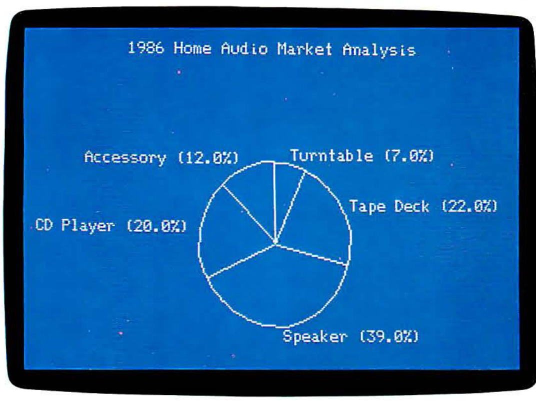
Here you highlight, expand, and compose text, charts, and illustrations drawn from a variety of programs. Then polish it all for printing.



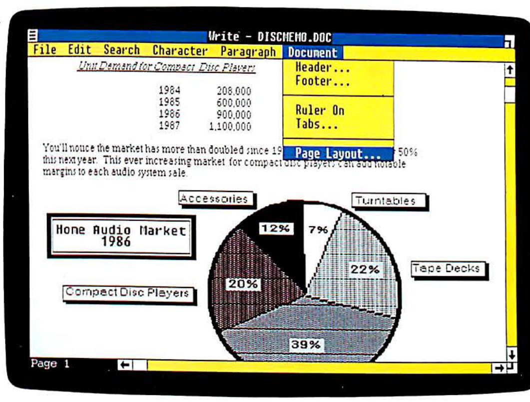
Spreadsheet information from Lotus® 1-2-3® can be captured. And then transferred to Windows Write, our graphic word processing program for consolidating, editing, and formatting.



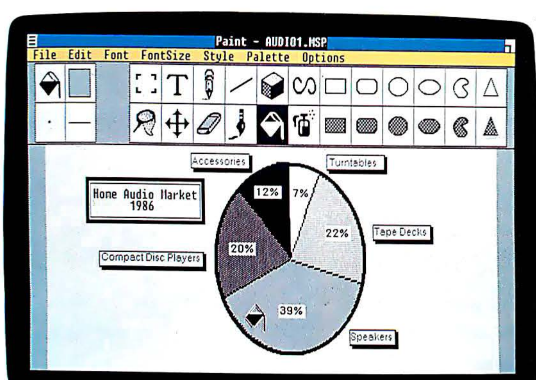
Data from dBase II® can also be copied and transferred to Write.



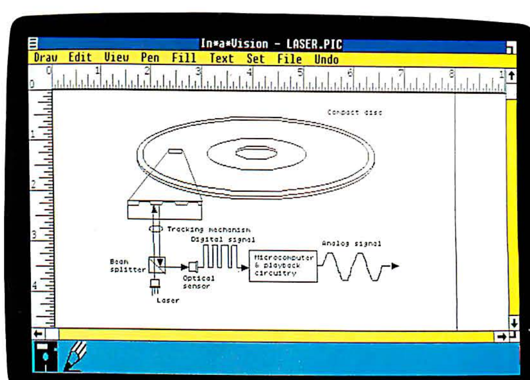
Using your spreadsheet data, build a Lotus chart. Then capture it from the screen. And paste it into Windows Paint.



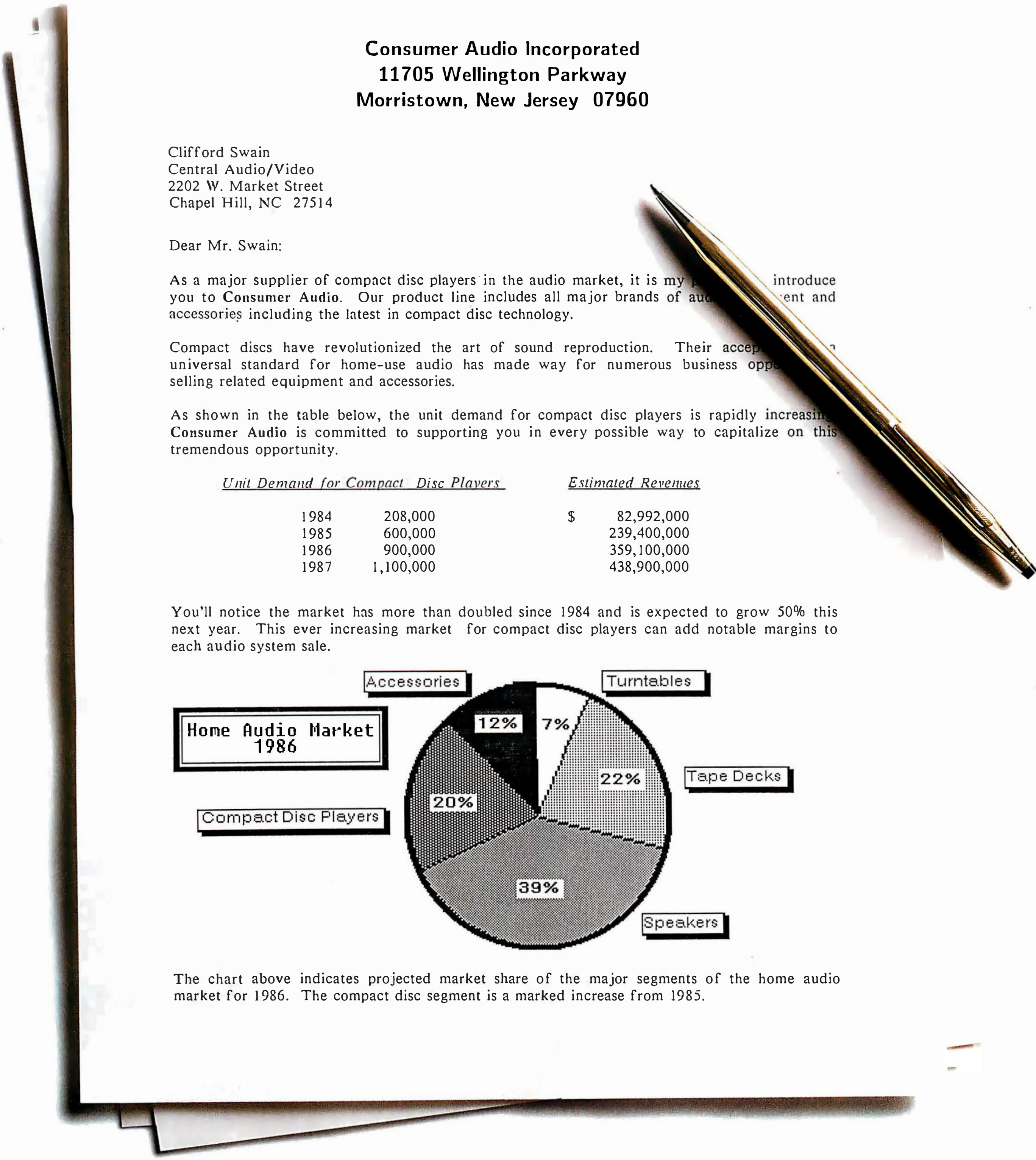
Windows Write is a straightforward and able word processor. It serves as the "great integrator" in Windows. The place where text and graphics from all your other programs are organized and formatted for presentation. What you see on the screen is what you'll get on the printout.



Windows Paint is an illustrator's studio. A palette of graphic tools. Use Paint to create drawings and diagrams. Or, in this case, to enhance a 1-2-3 chart to emphasize your point.



In-a-Vision, a Windows application by Micrografx, Inc., is a computer-aided design program. Its highly detailed technical illustrations are easily transferred to other Windows applications.



Consumer Audio Incorporated
11705 Wellington Parkway
Morristown, New Jersey 07960

Clifford Swain
Central Audio/Video
2202 W. Market Street
Chapel Hill, NC 27514

Dear Mr. Swain:

As a major supplier of compact disc players in the audio market, it is my ... introduce you to **Consumer Audio**. Our product line includes all major brands of au... ent and accessories including the latest in compact disc technology.

Compact discs have revolutionized the art of sound reproduction. Their accep... universal standard for home-use audio has made way for numerous business opp... selling related equipment and accessories.

As shown in the table below, the unit demand for compact disc players is rapidly increasin... **Consumer Audio** is committed to supporting you in every possible way to capitalize on this tremendous opportunity.

Unit Demand for Compact Disc Players		*Estimated Revenues*
1984	208,000	$ 82,992,000
1985	600,000	239,400,000
1986	900,000	359,100,000
1987	1,100,000	438,900,000

You'll notice the market has more than doubled since 1984 and is expected to grow 50% this next year. This ever increasing market for compact disc players can add notable margins to each audio system sale.

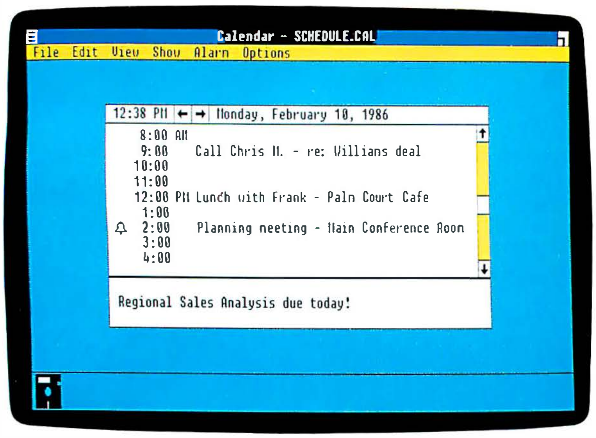
The chart above indicates projected market share of the major segments of the home audio market for 1986. The compact disc segment is a marked increase from 1985.

This is Windows' finished product. And it's highly finished, indeed. An exact representation of what you produced on-screen. The better your printer (in this case a laser) the better the results.

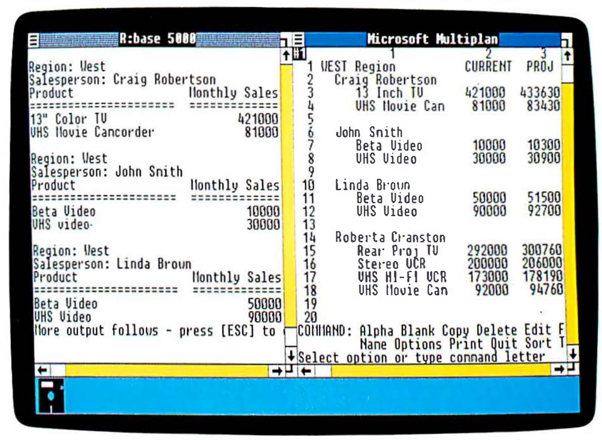
Spend a day with us. You'll

One of the great beauties of Windows is that in the here and now you enjoy the benefits of computing's future path—graphically oriented software. Without giving up any of the applications you're happy with today.

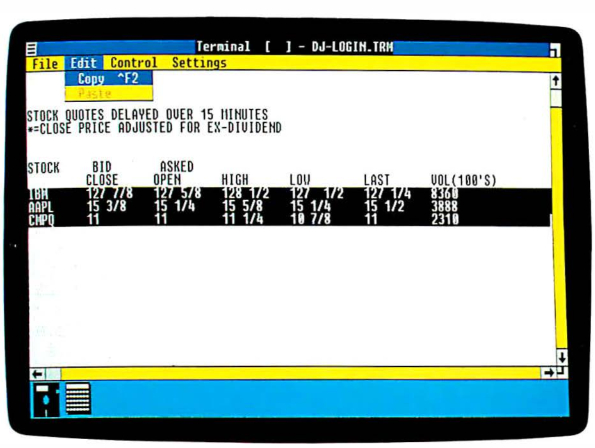
In addition to Windows Write and Paint, the Windows package includes a collection of desktop applications you can use to manage your day-to-day activities. A calendar, cardfile, notepad, calculator, and telecom-



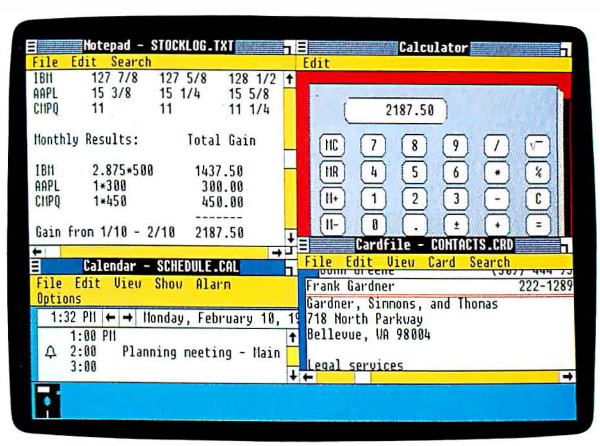
7:45 AM. Early as usual. Opening Windows lands you in the MS-DOS Executive, the Windows command center and file directory. Run the Windows Calendar program and see what's up for the day.



7:55 AM. You've got a report due by the end of the day. A comprehensive sales analysis. Bring up Multiplan® and R:BASE 5000® Copy regional sales data from R:BASE into Multiplan.



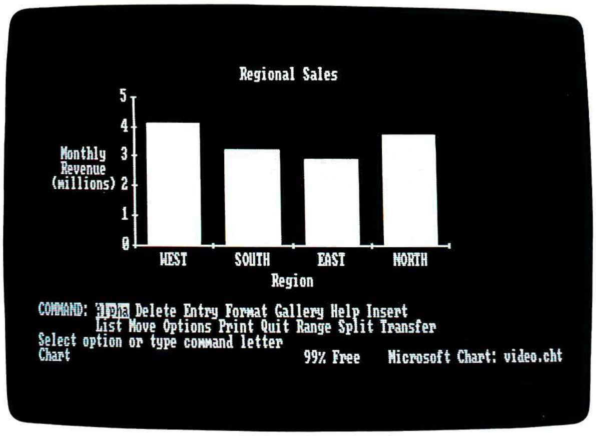
1:30 PM. Market's closed. How'd you do? Open Terminal to dial Dow Jones News/Retrieval® and check the final quotes. Copy and paste them into Notepad.



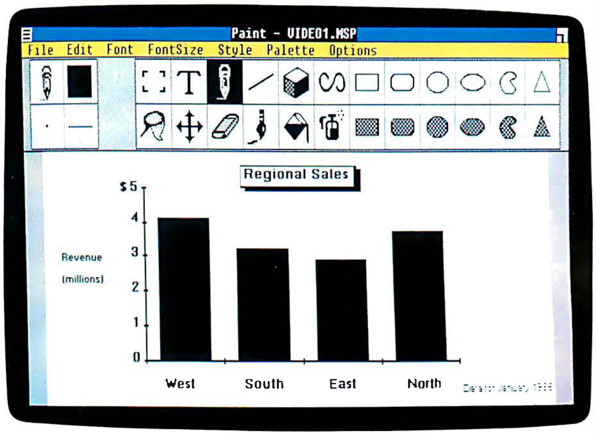
1:45 PM. You did pretty well today. So use the Windows Calculator to figure your gains. Which you duly note in Notepad. Your good luck, however, requires a call to your tax attorney. A quick click brings up his listing in Windows Cardfile. Another click dials him automatically on your modem.

never give up a Windows office.

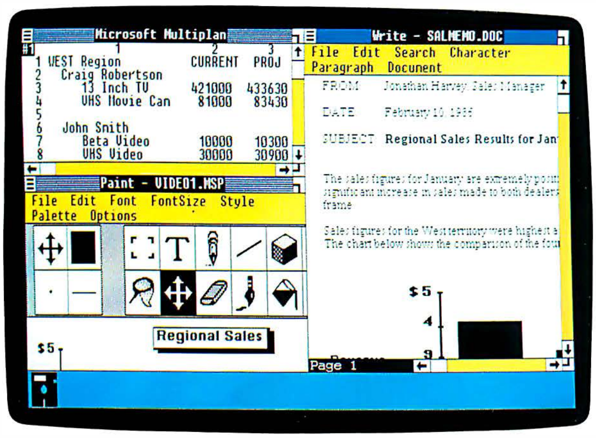
munications program, just to name a few.
Used together with your standard applications, they can handle an impressive list of office routines.
And because Windows runs standard DOS applications, you can look forward to the future.
But you don't have to wait on it.



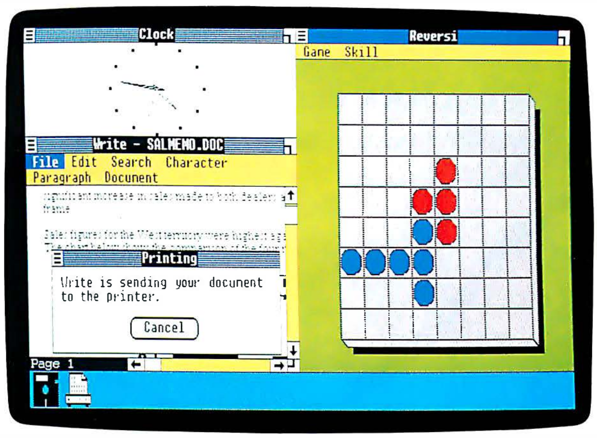
10:30 AM. You've squeezed everything you can out of the numbers. Now open up Microsoft Chart. And let the pictures tell the story. When you've made a chart fit for presentation, capture it from the screen.



11:00 AM. Paste your finished chart into Windows Paint. Add borders, highlights and illustrative detail. Not only more appealing, but more effective.



1:55 PM. No sooner do you hang up, than your Calendar alarm sounds. Checking the calendar, you find you've got a meeting at 2.
3:00 PM. The meeting went on forever. About time you got back to that report. Copy the chart from Paint, and paste it into Write. It looks brilliant. Now write it so it *sounds* brilliant.



4:48 PM. Everything on screen is looking good. You're ready to print. Open Clock to confirm time. That's right, it's tight. Choose the Print command and send the document off to the printer. Open Reversi for a quick game while you wait. While you beat the clock you can try beating the computer.
5:00 PM. Report printed impeccably. Turn it in and shut down for the day. After all, you were in fifteen minutes early.

The first reviews are in. Here's what they see in Windows.

Prominent reviewers and industry experts have been eagerly awaiting the arrival of Microsoft Windows.

Now they've had a good look. And we're pleased to record their responses to what they saw.

"I'll bet on Microsoft Windows."
Jonathan Sacks, West Coast editor of *Popular Computing* magazine.

"You've got a clear winner..."
Stewart Alsop, editor and publisher of *P.C. Letter.*

"...Windows looks very good..."
Peter Norton in his column in *PC WEEK* 9/24/85.

Of course, all this is going to cost you: $99.

A price that makes Windows the most startling value ever offered in software.

A comparable collection of programs—a switching program, a graphic interface, desktop applications, a word processor, a drawing program—could easily cost hundreds of dollars more.

Windows will instantly deliver you a more productive present. And a leap into the future.

A future which, frankly, we have no interest in keeping exclusive. At this price,* it looks to be arriving in a rush.

Check out the view.

We invite you to visit your Microsoft Dealer and get a screenful of Microsoft Windows. What you see will confirm what others have said, Windows is clearly a winner.

*Price valid only in the U.S.A.

Integration features:
- Work with multiple applications and switch between them.
- Run more applications than fit in memory at one time.
- Consolidate information from standard DOS and Windows applications.

Applications included:
- MS-DOS Executive—DOS file management program. Run programs; format disks; copy, rename, delete files.
- Calendar—Set appointments with optional alarm reminders; daily or monthly view.
- Cardfile—Filing program; cards can include text or graphics, autodial capability.*
- Notepad—Text scratch pad/editor; time/date stamp option.
- Terminal—Telecommunications program; copy session data to other programs or capture to file; autodial capability.*
- Calculator—Common arithmetic operations, plus square root, percent, and memory.
- Clock—Can be displayed anywhere on the screen.
- Reversi—Strategy game; four levels of play.
- Control Panel—Set time, date, communication ports, colors, add/delete printers.
- Program Information File (PIF) Editor—Create or edit PIF files for standard applications.
- Print Spooler—Print files from Windows applications while running other programs.
- Clipboard—View information copied from applications.
- RAMDrive—Setup memory expansion cards as a RAM disk.

Introductory offer also includes:
- Windows Write—Graphics based word processor.
- Windows Paint—A full-featured drawing program.

System Requirements:
- IBM or COMPAQ® Personal Computer 256K memory, DOS 2.0 or higher, two double-sided disk drives, graphics adapter card (IBM Color/Graphics Monitor Adapter, IBM Enhanced Graphics Adapter, Hercules Graphics Card, COMPAQ Personal Computer Graphics Display Adapter, or compatible).

Note:
- 512K memory and a hard disk are recommended when using multiple applications or DOS 3.0 or higher.

*requires a Hayes compatible modem

International Offices

Microsoft Corporation
Bellevue, Washington USA

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Reading ENGLAND

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Microsoft Canada Inc.
Toronto CANADA

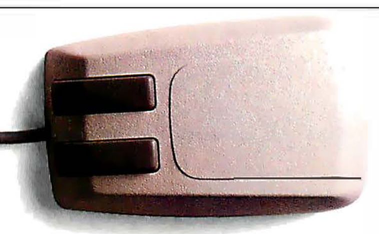
Microsoft Pty
Sydney NSW AUSTRALIA

Microsoft AB
Stockholm SWEDEN

Microsoft SARL
Paris FRANCE

Microsoft Far East
Tokyo JAPAN

QNIX Microsoft
Seoul KOREA



You can run Windows with either keyboard commands or by a mouse and keyboard together. Windows admirably exploits the mouse's speed, mobility, and simplicity.

Microsoft® Windows

The High Performance Software™

NOTE: Photos show color and resolution obtained on an IBM® PC equipped with IBM Enhanced Graphics Adapter. Monochrome display is generated when an IBM Color/Graphics Adapter or compatible graphics adapter card is used.

For the name of your nearest Microsoft dealer, call (800) 426-9400. In Washington State and Alaska, (206) 828-8088. In Canada, call (800) 387-6616.

0186 Part No. 098-050-202

UPDATES

Conferencing Contacts

Brock N. Meeks's "An Overview of Conferencing Systems" in our December 1985 issue (page 169) described a variety of computer conferencing systems. However, the article did not include addresses or telephone numbers of the companies mentioned. Here now is that information. (For more on conferencing systems, see Letters, page 30.)

System	Availability	System	Availability
PARTICIPATE Participation Systems Inc. 50 Cross St. Winchester, MA 01890 (617) 729-1976	Various information networks; may be licensed	EIES Electronic Information Exchange System New Jersey Institute of Technology 323 High St. Newark, NJ 07102 (201) 420-5111	Telenet, Uninet, or direct dial
GENIE Data Dynamics Inc. POB 2728 Portland, OR 97208 (503) 626-4635	No subscription service; may be licensed or rented	eForum Network Technologies International 315 West Huron Ann Arbor, MI 48103 (313) 994-4030	GESICO; may be licensed
NOTEPAD Infomedia 801 Trager Ave., Suite 275 San Bruno, CA 94066 (415) 952-4487	Tymnet; may be licensed	CONFER Advertel Communication Systems 2067 Ascot Ann Arbor, MI 48103 (313) 665-2612	Telenet
AUGMENT Tymshare 20705 Valley Green Dr. Cupertino, CA 95014 (408) 446-6000	Tymnet; may be licensed	CoSy Institute of Computer Science University of Guelph Guelph, Ontario N1G 2W1 Canada (519) 824-4120 ext. 3712	BYTE Information Exchange; Tymnet
COM Swedish National Defense Research Institute Stockholm University Computing Center Box 27322 S-102 54 Stockholm, Sweden Telephone: 46 8 679280	Tymnet; no subscription service; may be licensed		

BYTE'S BITS

Free FORTH Reference Card

This little card from the FORTH Interest Group (FIG) is a useful aid for programming. The FORTH reference card lists the required commands of the FORTH-83 standard. Commands are grouped by function, such as stack manipulation, comparison, strings, numeric conversion, compiler and interpreter words, and vocabularies.

FIG is a nonprofit organization with more than 5000 members. It costs $20 to join, which includes a subscription to the group's bimonthly publication, *FORTH Dimensions*. The reference card is free to anyone. Just contact FIG at POB 8231, San Jose, CA 95155, or phone the FIG Hot Line at (408) 277-0668.

BYTE'S BUGS

Changes in Ciarcia's Cellar

A few changes to Ciarcia's Circuit Cellar in the March issue. On page 118, the telephone number for Dallas Semiconductor should be (214) 450-0449. In figure 6 on that same page, the two capacitor symbols should be battery symbols. And on page 119, last paragraph, chip model DS1224 should read DS1221.

The personal computer that raised high performance to new heights.

If you work with high volumes of information, you need answers fast.

You need a personal computer that's up to the task.

Which is why IBM created the Personal Computer AT® system. It's changed a lot of ideas about business computing.

The idea of "fast" has become much faster. The idea of "data capacity" has become far greater.

There are new definitions of "power" in a stand-alone PC. While phrases like "sharing files" and "multi-user systems" are being heard more often.

And surprisingly, words like "affordable" and "state-of-the-art" are being used *together.*

Clearly, the Personal Computer AT is different from anything that came before. And what sets it apart can be neatly summed up in two words.

Advanced Technology.

If you've ever used a personal computer before, you'll notice the advances right away.

To begin with, the Personal Computer AT is extraordinarily fast. That's something you'll appreciate every time you recalculate a spreadsheet. Or search through a data base.

It can store mountains of information—literally thousands of pages' worth—with a single "hard file" (fixed disk). And now you can customize your system to store up to 30,000 pages with the addition of a *second* hard file.

The Personal Computer AT runs many of the thousands of programs written for the IBM PC family. Like IBM's TopView, the program that lets you run and "window" several other programs at once.

Perhaps best of all, it works well with both the IBM PC and PC/XT. Which is welcome news if you've already made an investment in computers.

You can connect a Personal Computer AT to the IBM PC Network, to share files, printers and other peripherals with other IBM PCs.

You can also use a Personal Computer AT as the centerpiece of a three-user system, with your existing IBM PCs as workstations.

Most important, only the Personal Computer AT offers these capabilities *and* IBM's commitment to quality, service and support. (A combination that can't be cloned.)

If you'd like to learn more about the IBM Personal Computer AT, see your Authorized IBM PC Dealer, IBM Product Center or IBM marketing representative. For a store near you, call 1-800-447-4700 (in Alaska, call 1-800-447-0890).

The IBM Personal Computer AT, for Advanced Technology.



We've Earned The Right To Be #1

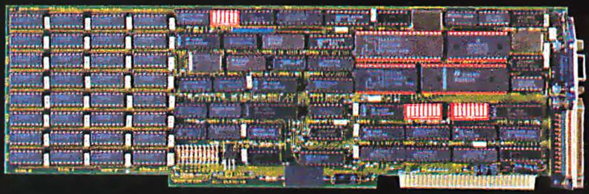
By Being First So Often

When it comes to being FIRST with technology-leading products ***Advanced Digital*** wears its #1 button with pride. We were ***FIRST*** to introduce an 8-Bit, single board S-100 computer... We were ***FIRST*** to introduce a 6MHz, 128KByte single board computer... We were ***FIRST*** to introduce a 6MHz, 128KByte Slave Processor board. Our record of ***FIRSTS*** continues with...

- The introduction of MULTI SLAVE – a 3 USER, 8MHz SLAVE card for the S-100 Bus systems running Turbo-Dos™ or NETWORK/OS.™
- The introduction of HDC-2001, the all new hard disk controller for the S-100 BUS.
- The introduction of SUPER 16, a 16-Bit, S-100 Slave card for use with Turbo-Dos or NETWORK O/S.
- The introduction of our new SUPER 186 – the ***FIRST*** 16-Bit, single board S-100 computer that performs at twice the speed of older technologies. Loaded with features such as on-board floppy disk controller and up to 1MByte of RAM, the SUPER 186 is designed to function as a bus Slave or Master. Advanced Digital's SUPER 186 permits you to take advantage of vast libraries of sophisticated applications software.

Again, we were #1 with...

- The introduction of PC-SLAVE, an IBM PC Multiuser card with 8088 (8MHz) CPU and 256-768K RAM on board.

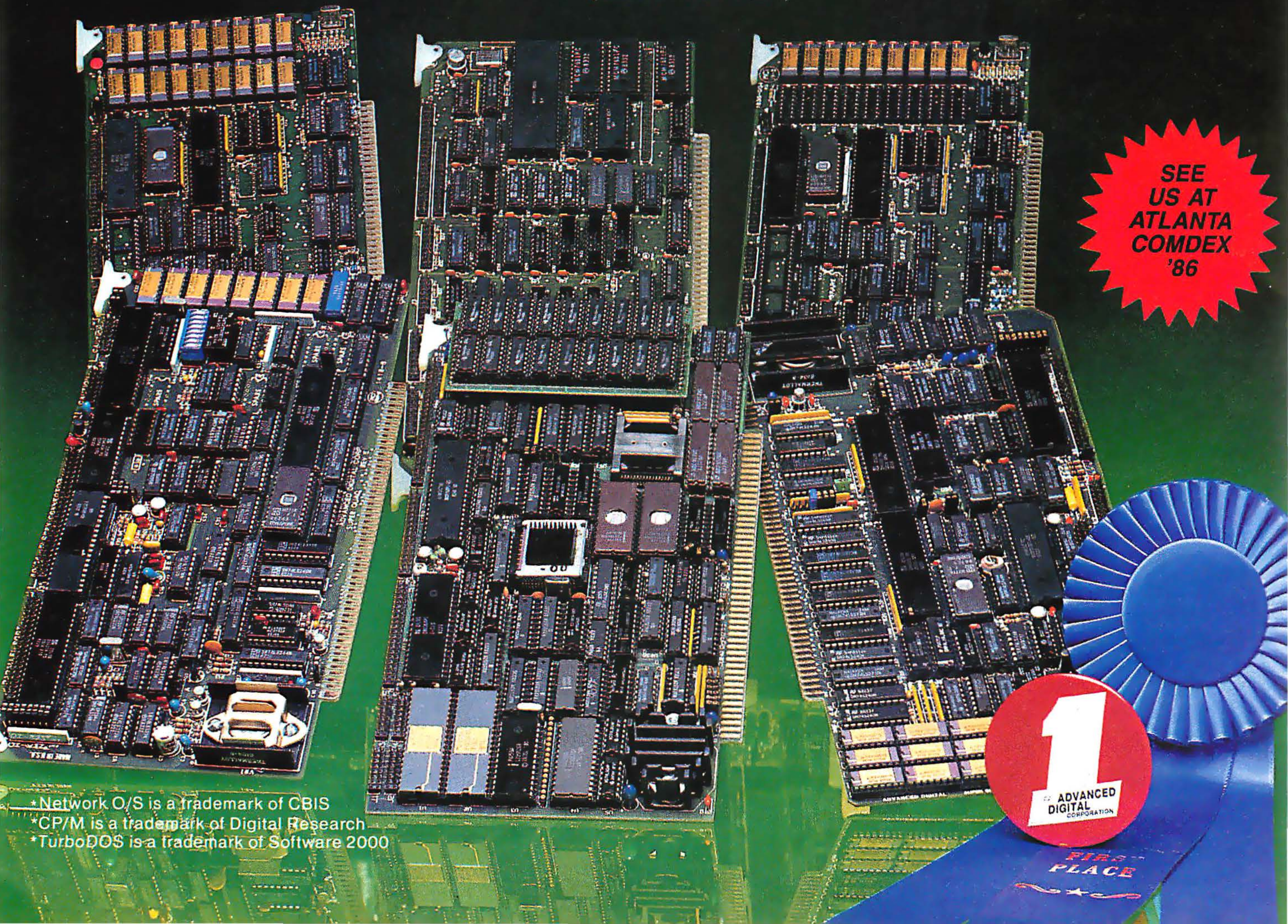


When it comes to selecting your S-100 boards, go with Advanced Digital – the recognized industry leader.

See your local computer dealer or contact Advanced Digital today for more information on the new PC-SLAVE, and the complete line of S-100 single board computers and multiuser systems.

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*Network O/S is a trademark of CBIS
*CP/M is a trademark of Digital Research
*TurboDOS is a trademark of Software 2000

Hi-Res Color Workstation Runs Two UNIX Standards

Apollo Computer's Domain Series 3000 Personal Workstation combines 32-bit computing, high-resolution color graphics, and integrated networking capabilities. The workstation comes with Apollo's Domain/IX software, which is based on AT&T's UNIX System V and enables that UNIX and Berkeley 4.2 to run as coresident operating systems.

The Series 3000 uses the 68020 processor and 68881 floating-point chip. Memory capacity ranges from 2 to 4 megabytes, and large-program capability is provided by 64 megabytes of virtual address space per process (for as many as 24 processes).

Equipped with an external bus that's compatible with the IBM PC AT, the workstation has six 16-bit slots and two 8-bit slots. Apollo says it has in the works a coprocessor for running IBM PC applications.

The color versions of the Series 3000 offer resolution of 1024 by 800 pixels on a 15-inch monitor; the basic model, with 2 megabytes of main memory, costs $14,900. The monochrome models offer resolution of 1280 by 1024 pixels on a 19-inch monitor; the basic version, with 2 megabytes of main memory, costs $9900. For more information, contact Apollo Computer Inc., 330 Billerica Rd., Chelmsford, MA 01824, (617) 256-6600.
Inquiry **550.**



Apollo's Domain Series 3000 Personal Workstation.

CD-ROM Hardware with Encyclopedia Disk

Activenture's Personal Information Package consists of a CD-ROM player, a controller card and connecting cable, the Grolier Electronic Encyclopedia on a compact disk, and software that lets you search for and retrieve information. The system works with IBM PCs and compatibles having at least 256K bytes of memory.

With the Knowledge Retrieval System (KRS) software, you can search—by word, name, phrase, or topic—the disk version of the 21 volumes of Grolier's Academic American Encylopedia. According to Activenture, locations of any word (there are more than 9 million of them) in the encyclopedia can be found in seconds through KRS.

The ROMulus CD-ROM drive has a data capacity of 540 megabytes per disk and can be connected to any IBM PC, XT, AT, or compatible through a controller card that fits in an open expansion slot.

The complete hardware/software package sells for $995, but you can buy just the CD-ROM player and controller for $849 and the encyclopedia disk/KRS software for $199. Contact Activenture Corp., POB 51125, Pacific Grove, CA 93950, (408) 375-2638.
Inquiry **551.**

PC Board Designer for Atari ST

Abacus Software has a program for designing printed circuit boards with an Atari 520ST or 1040ST. PCBoard Designer, developed by Data Becker GmbH of West Germany, features an automatic routing capability. Traces are drawn automatically on the screen, and if you change your design, the trace can be immediately redrawn. Options allow for 45- or 90-degree angle traces, different widths, routing from pin to pin, from pin to bus, bus to bus, and two-sided boards.

You first define the components that are part of the board and enter the information at the keyboard. Next, you define the connections. Using the mouse, you then place the components on the screen. You can change or reposition the components or connections at any time.

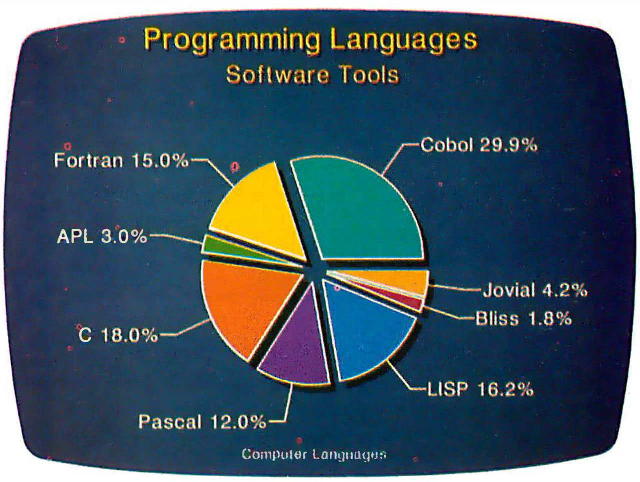
PCBoard Designer prints the layout to any Epson or compatible dot-matrix printer. According to Abacus, printouts are suitable for photoetching. You can also print the component layout and a list of components and connections.

(continued)

Suggested retail price of PCBoard Designer is $395. Contact Abacus Software, 2201 Kalamazoo SE, POB 7211, Grand Rapids, MI 49510, (616) 241-5510.
Inquiry 552.



Image created with Harvard Presentation Graphics.



Pie chart and text generated with Graftime.

Presentation Graphics Program

Harvard Presentation Graphics, the initial offering in Software Publishing's Harvard software line, lets you combine text, graphs, and charts in one image and create a slide show on the computer screen. The package has 13 kerned fonts, a selection of 16 colors, and formatting and layout options that include three-dimensional graphs and large text. An editor lets you incorporate text and symbols in charts.

The program reads Lotus spreadsheet data and graphs directly. It also reads pfs:Graph and ASCII files and can export files to pfs:Write.

Harvard Presentation Graphics runs on MS-DOS computers and requires 256K bytes of memory. It works with the Enhanced Graphics Adapter card and a variety of printers, plotters, and film recorders. Retail price is $395. Contact Software Publishing Corp., 1901 Landings Dr., Mountain View, CA 94043, (415) 962-8910.
Inquiry 553.

Genigraphics has also released a program for generating presentation-style graphics. Graftime uses preformatted business graphics and a "forms-fill menu interface"; you select a predefined format for your graph or chart and then enter the information you want to convey. Graphics can be output as printed copy, overhead transparency, or 35mm slide.

Graftime offers 14 types of charts, five color palettes, and eight choices for handling attributes. For constructing sequenced slides, the package has an automatic build function.

The software costs $395 and runs on the IBM PC line and compatibles with at least 448K bytes of memory and DOS 2.0 or later. To use the program's previewing option, you need a graphics card. Contact Genigraphics Corp., POB 591, Liverpool, NY 13088, (315) 451-6600.
Inquiry 554.

Animation System for the Macintosh

MacMovies, a high-resolution animation package from Beck-Tech that runs on the Apple Macintosh and Macintosh Plus, accepts hand-drawn, prestored, or digitized (with a camera or tablet) images, compresses and stores them on a floppy or hard disk, and plays them back as animated sequences. Playback rate is adjustable from 1 to 30 frames per second. If your Mac has a 1- or 2-megabyte memory board inside for picture storage and you've set the playback speed at 10 fps, MacMovies can show as much as 30 seconds of continuous animation if the images are complex and as much as 90 seconds of footage if the images are simple. With a hard disk, you can link sequences and make a longer movie.

You can create cartoons using MacDraw or MacPaint and cel animation techniques (a cel is a single image of a sequence, and cel-by-cel animation involves rapidly changing these individual images). MacMovies can provide full-motion pictures with multiple moving objects and moving backgrounds.

MacMovies requires at least 512K bytes. Suggested retail price is $99. Disks of premade flicks are available for $29.95 in monochrome and $39.95 in color: "Have a Heart" shows the operation of the human heart; "The Moving Motor" demonstrates the workings of an internal-combustion engine.

Beck-Tech is also selling MacAnimation Station, a turnkey animation system that packages a Macintosh with 1 megabyte of memory, MacMovies, MacPaint, Click-Art images, and a pen-based digitizer tablet for $4995. Options include the company's Chromatron converter for color display, 10- or 20-megabyte hard disk, and 2-megabyte memory. Contact Beck-Tech Corp., 41 Tunnel Rd., Berkeley, CA 94705, (415) 548-4054.
Inquiry 555.

(continued)

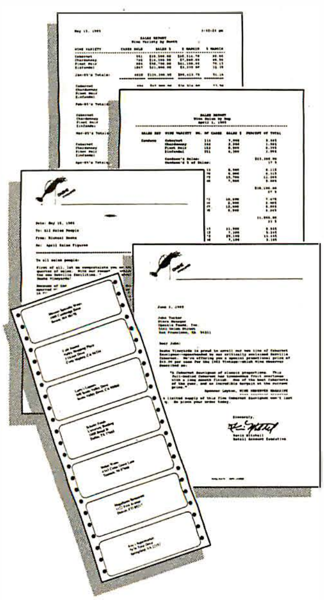
Using Lotus 1-2-3® without Reflex is like driving at night without lights

If you use Lotus 1-2-3 you need Reflex, the Analyst™ because it shows you what 1-2-3 either hides in the dark or can't show you at all. Reflex shows you relationships and inter-relationships in your data that you can't afford to miss.

Reflex includes the best Report Generator for Lotus 1-2-3.

Reflex includes the Report Generator that 1-2-3 should have included — but didn't. With Reflex, you can generate reports, graphs, charts and diagrams *from* your 1-2-3 worksheets that are impossible to generate *with* 1-2-3.

You can do sales reports, letters, memos, invoices and mailing labels — to name a few — and you can see a few of them on this page.



Reflex is the best database for 1-2-3 users and it's also the easiest to use.

Reflex is the first database that separates the trees from the forest. The first database that understands that what you see depends on how you look at it.

The first database that probes relationships — then shows them to you in various graphic forms — scatter, line, bar, stacked bar and pie charts. The first database to break the bonds of traditional database management and give a dramatic visual turn to data analysis.

Reflex makes graphic leaps far beyond 1-2-3. With Reflex, when you look, you see.

Reflex gives you five new and different views of what's hidden in your 1-2-3 worksheets.

Form View, *List* View, *Graph* View, *CrossTab* and *Report* View.

Form View lets you create your database. *List* View shows you your data in tabular list form, just like a spreadsheet. *Graph* View gives you instant interactive graphic representations; *CrossTab* View gives you amazing "cross-referenced" pictures of the links and relationships hidden in your data. *Report* View allows you to use information from 1-2-3, and then print out reports in all sorts of different formats.

The commands for all five Views are consistent — so you're not stuck learning five different ways to get something done. And because Reflex uses advanced windowing techniques, you can see several views on the screen at the same time — without having to switch back and forth. You get the picture, and the pictures, all at once.

Whether you're a 1-2-3 user or not, Reflex answers all your "What Ifs?" and leads you to the right conclusions.

With Reflex when you modify a number all your Views — List, Form and Graph — are immediately updated, on-screen.

Let's say you're analyzing "*Traveling Expenses by Salesperson*" and you ask, "What if they stayed at a *Motel 5¼* instead of the Presidential Suite of the *Hotel Chic*?" "Show me." So Reflex shows you.

"What if they could no longer order $100 wines, but had to stick to the stuff that matures in the truck?" "Show me." So Reflex shows you. Instant answers. Instant pictures. Instant analysis. Instant understanding.

Of course Reflex can do all of the above with or without 1-2-3. Reflex is a *complete* database management and analytical tool that stands on its own feet and helps you stay on yours because it's only $99.95!

Borland's $99.95 Reflex could be the best business investment you'll ever make.

Buying 1-2-3 was a good idea. Reflex is an even better idea because now you can see what you're doing, what you've done, and what you need to do.

Think of Reflex as an "automatic product," a "standard" that every up-to-speed PC owner should have on hand. It's only $99.95, and *you* get our 60-day money-back guarantee.

We don't believe in copy-protection, but we do believe in quality, performance and reasonable software prices. So keep driving your old 1-2-3, but get Reflex today, because then you can see where you're going.

"Everyone agrees that Reflex is the best-looking database they've ever seen"

Adam B. Green, InfoWorld

"The next generation of software has officially arrived"

Peter Norton, PC Week

YES! Rush Reflex to me.

Send me ______ copies at:

$99.95

This price includes shipping to all U.S. cities.

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Outside USA add $10 per copy
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R15

System requirements: *IBM® PC, XT, AT, or compatibles. 384K RAM minimum. IBM Color Graphics Adapter®, Hercules Monochrome Graphics Card™, or equivalent. PC DOS® 2.0 or greater. Hard disk and mouse optional.*

CODs and Purchase Orders WILL NOT be accepted by Borland. California residents add 6% sales tax. Outside USA add $10 per copy and make payment by bank draft payable in US dollars drawn on a US bank.



Inquiry 37 for End-Users. Inquiry 38 for DEALERS ONLY.

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SCOTTS VALLEY, CA 95066
(408) 438-8400 TELEX: 172373

CAD Software for IBM PCs, Compatibles

Foresight Resources has released a package for two-dimensional drafting and designing with an IBM PC, XT, or AT and most compatibles. Called Drafix I, it sells for $295 alone, $395 with a mouse, and $585 with a 12- by 12-inch plotter.

Input techniques for lines, arcs, circles, fillets, and chamfers include grid and angle locks, snap locks to item endpoints, midpoints, intersections, and tangents. Copy and move operations let you translate, rotate, scale, and mirror. Flexible numeric input, combined with the program's calculation capabilities, provides you with areas, perimeters, angles, coordinates, and other drawing information.

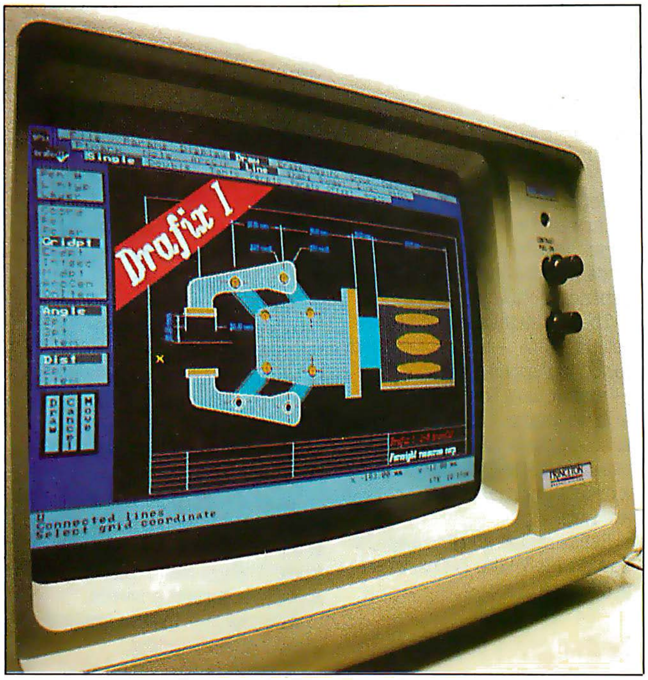
Among additional drawing attributes are 16 pen colors, 256 layers, 8 line types, and 12 text fonts. Resetting, zooming, and panning capabilities let you control the view.

The visual interface makes extensive use of icons, and a menu of drawing and program options is on the screen at all times.

Although Drafix I can stand alone, Foresight Resources has developed a utility that enables a Drafix-generated drawing to be used on an AutoCAD workstation (from Autodesk Inc.). The AutoCAD File Exchange Utility costs $95.

Written in Lattice C, Drafix I runs under PC-DOS 2.1 or later and requires at least 512K bytes; Foresight recommends at least 640K bytes and a math coprocessor. Other requirements are an RS-232C port and a mouse or digitizer. The software works with a variety of graphics cards, printers, and plotters (up to "C" size). For more information, contact Foresight Resources Corp., 932 Massachusetts St., Lawrence, KS 66044, (800) 231-8574; in Kansas (913) 841-1121.

Inquiry 556.



Drafix I, a drafting package from Foresight Resources.

Outline Processor for CP/M Machines

KAMASOFT has taken the programming language out of KAMAS (see review on page 241), its outline tool for CP/M computers, added some features, enhanced the interface, and packaged it as Out-Think. This full-screen outline editor has collapse and expand capabilities and comes with a text editor for working with prose in the outline.

The outline processor allows a maximum topic size of 8 megabytes; there's no limit, other than disk space, to the number of items per file, items per level, or levels per file. You can jump from topic to topic and copy branches within and between topics. The maximum number of topics you can access at one time is 16.

With the program's retrieval capabilities, you can search for information by keywords or by similar-sounding keywords. Six methods are provided for querying accessible text. You can read and write text files compatible with most well-known word processors and print an outline with more than 20 formatting parameters. The package automatically generates a table of contents. Among other features are a file manager, date and time stamping, and password security.

Out-Think can run on most computers equipped with CP/M version 2.2 or later, including machines with 8080, 8085, and Z80 processors. It needs at least 48K bytes of RAM and an 80-column by 24-line screen. Suggested retail price is $49.95. KAMAS owners can get Out-Think by sending in their master disk and $25. Contact KAMASOFT Inc., 2525 Southwest 224th Ave., Aloha, OR 97006, (503) 649-3765.

Inquiry 557.

MIDI Sequencer for Apple II+, IIe

Synthestra, a MIDI sequencer and controller program for the Apple II+ and IIe, brings a complete MIDI system under the control of one synthesizer keyboard. Each key on the MIDI-equipped master unit can be independently assigned to any voice of any synthesizer in the system. You can control as many as 16 keyboards, drum machines, expanders, or other MIDI devices from one keyboard.

The sequencer supports 100 sequences with 16 tracks each. You can assign any key to start, stop, loop, and sync any sequence or combination of sequences. This capability enables you to play one-finger chords and special effects. Other features include 100 definable patches for matching presets to MIDI channels, independent key transposition, loading and saving to disk, and unlimited keyboard splitting, doubling, tripling, and echoing.

To use Synthestra with an Apple, you need at least 64K bytes, one disk drive, one monitor, one MIDI interface card (Decillionix, Passport, Syntech, Yamaha, or equivalent), and at least one MIDI-equipped keyboard. The price is $120. Contact Decillionix, POB 70985, Sunnyvale, CA 94086, (408) 732-7758.

Inquiry 558.

(continued)

The C for Microcomputers

AZTEC C

PC-DOS, MS-DOS, CP/M-86, Macintosh, Amiga, Apple II, CP/M-80, Radio Shack, Commodore, XENIX, ROM, and Cross Development systems

MS-DOS, PC-DOS, CP/M-86, XENIX, 8086/80x86 ROM

Manx Aztec C86

"A compiler that has many strengths ... quite valuable for serious work"

Computer Language review, February 1985

Great Code: Manx Aztec C86 generates fast executing compact code. The benchmark results below are from a study conducted by Manx. The Dhrystone benchmark (CACM 10/84 27:10 p1018) measures performance for a systems software instruction mix. The results are without register variables. With register variables, Manx, Microsoft, and Mark Williams run proportionately faster, Lattice and Computer Innovations show no improvement.

	Execution Time	Code Size	Compile/ Link Time
Dhrystone Benchmark			
Manx Aztec C86 3.3	34 secs	5,760	93 secs
Microsoft C 3.0	34 secs	7,146	119 secs
Optimized C86 2.20J	53 secs	11,009	172 secs
Mark Williams 2.0	56 secs	12,980	113 secs
Lattice 2.14	89 secs	20,404	117 secs

Great Features: Manx Aztec C86 is bundled with a powerful array of well documented productivity tools, library routines and features.

Optimized C compiler	Symbolic Debugger
AS86 Macro Assembler	LN86 Overlay Linker
80186/80286 Support	Librarian
8087/80287 Sensing Lib	Profiler
Extensive UNIX Library	DOS, Screen, & Graphics Lib
Large Memory Model	Intel Object Option
Z (vi) Source Editor -c	CP/M-86 Library -c
ROM Support Package -c	INTEL HEX Utility -c
Library Source Code -c	Mixed memory models -c
MAKE, DIFF, and GREP -c	Source Debugger -c
One year of updates -c	CP/M-86 Library -c

Manx offers two commercial development systems, Aztec C86-c and Aztec C86-d. Items marked -c are special features of the Aztec C86-c system.

Aztec C86-c Commercial System	**$499**
Aztec C86-d Developer's System	**$299**
Aztec C86-p Personal System	**$199**
Aztec C86-a Apprentice System	**$49**

All systems are upgradable by paying the difference in price plus $10.

Third Party Software: There are a number of high quality support packages for Manx Aztec C86 for screen management, graphics, database management, and software development.

C-tree $395	**Greenleaf $185**
PHACT $250	**PC-lint $98**
HALO $250	**Amber Windows $59**
PRE-C $395	**Windows for C $195**
WindScreen $149	**FirsTime $295**
SunScreen $99	**C Util Lib $185**
PANEL $295	**Plink-86 $395**

MACINTOSH, AMIGA, XENIX, CP/M-68K, 68k ROM

Manx Aztec C68k

"Library handling is very flexible ... documentation is excellent ... the shell a pleasure to work in ... blows away the competition for pure compile speed ... an excellent effort."

Computer Language review, April 1985

Aztec C68k is the most widely used commercial C compiler for the Macintosh. Its quality, performance, and completeness place Manx Aztec C68k in a position beyond comparison. It is available in several upgradable versions.

Optimized C	Creates Clickable Applications
Macro Assembler	Mouse Enhanced SHELL
Overlay Linker	Easy Access to Mac Toolbox
Resource Compiler	UNIX Library Functions
Debuggers	Terminal Emulator (Source)
Librarian	Clear Detailed Documentation
Source Editor	C-Stuff Library
MacRam Disk -c	UniTools (vi,make,diff,grep) -c
Library Source -c	One Year of Updates -c

Items marked -c are available only in the Manx Aztec C86-c system. Other features are in both the Aztec C86-d and Aztec C86-c systems.

Aztec C68k-c Commercial System	**$499**
Aztec C68d-d Developer's System	**$299**
Aztec C68k-p Personal System	**$199**
C-tree database (source)	**$399**
AMIGA, CP/M-68k, 68k UNIX	**call**

Apple II, Commodore, 65xx, 65C02 ROM

Manx Aztec C65

"The AZTEC C system is one of the finest software packages I have seen"

NIBBLE review, July 1984

A vast amount of business, consumer, and educational software is implemented in Manx Aztec C65. The quality and comprehensiveness of this system is competitive with 16 bit C systems. The system includes a full optimized C compiler, 6502 assembler, linkage editor, UNIX library, screen and graphics libraries, shell, and much more. The Apple II version runs under DOS 3.3, and ProDOS, Cross versions are available.

The Aztec C65-c/128 Commodore system runs under the C128 CP/M environment and generates programs for the C64, C128, and CP/M environments. Call for prices and availability of Apprentice, Personal and Developer versions for the Commodore 64 and 128 machines.

Aztec C65-c ProDOS & DOS 3.3	**$399**
Aztec C65-d Apple DOS 3.3	**$199**
Aztec C65-p Apple Personal system	**$99**
Aztec C65-a for learning C	**$49**
Aztec C65-c/128 C64, C128, CP/M	**$399**

Distribution of Manx Aztec C

In the USA, Manx Software Systems is the sole and exclusive distributor of Aztec C. Any telephone or mail order sales other than through Manx are unauthorized.

Manx Cross Development Systems

Cross developed programs are edited, compiled, assembled, and linked on one machine (the HOST) and transferred to another machine (the TARGET) for execution. This method is useful where the target machine is slower or more limited than the HOST. Manx cross compilers are used heavily to develop software for business, consumer, scientific, industrial, research, and educational applications.

HOSTS: VAX UNIX ($3000), PDP-11 UNIX ($2000), MS-DOS ($750), CP/M ($750), MACINTOSH ($750), CP/M-68k ($750), XENIX ($750).

TARGETS: MS-DOS, CP/M-86, Macintosh, CP/M-68k, CP/M-80, TRS-80 3 & 4, Apple II, Commodore C64, 8086/80x86 ROM, 68xxx ROM, 8080/8085/Z80 ROM, 65xx ROM.

The first TARGET is included in the price of the HOST system. Additional TARGETS are $300 to $500 (non VAX) or $1000 (VAX).

Call Manx for information on cross development to the 68000, 65816, Amiga, C128, CP/M-68K, VRTX, and others.

CP/M, Radio Shack, 8080/8085/Z80 ROM

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80-Micro, December, 1984, John B. Harrell III

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Inquiry 201

MANX

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IBM RT PC Based on RISC Architecture

IBM's RT PC workstation is the company's first product incorporating its RISC (reduced instruction set computer) architecture, based on research begun at Big Blue in the 1970s. The machine's advanced functions are implemented on two IBM-developed NMOS chips: a 32-bit RISC processor and the system's memory management unit. The processor can execute 118 instructions, 84 of them in a single machine cycle, or pulse. In the RT PC, this pulse is approximately 170 nanoseconds. Instead of instructions that can take several cycles, software for the RT allows complex tasks to be assembled from a set of simple instructions. The instruction set also lets software use general-purpose registers to minimize the processor's need to access memory for data.

IBM says that a data path between the MMU and the 32-bit chip, which can handle multiple requests for data and instructions, makes access to memory more efficient. Traffic between the processor and memory can be pipelined; hence, multiple requests shouldn't cause delays.

The RT's microprocessor refers to memory about 3 to 4 million times per second. According to IBM, this can be done efficiently because of two proprietary developments: a two-stage "memory-mapping" facility and an "inverted page table" (which essentially keeps only real memory addresses). These features reportedly raise addressing capability to 40 bits and let the processor address as many as 1 trillion bytes of virtual storage.

The series runs under an operating system called Advanced Interactive Executive (AIX), which is similar to UNIX System V.



IBM's RT PC 6151 *model 10 with color display.*

The line begins with a desktop unit called the RT PC 6151 model 10, about the size of a PC and packaged with 1 megabyte of memory (expandable to 3 megabytes) and 40 megabytes of fixed-disk capacity. Prices begin at $11,700. Three floor-standing models are also available; their prices run in the range of $14,000 to $20,000. All RTs have an AT-compatible 16-bit I/O bus. For more information, contact your local IBM marketing representative (listed in the telephone book).

Inquiry **559.**

RGB Card Beefs Up Apple IIe

Checkmate Technology's MultiRam RGB card fits into the auxiliary slot on the Apple IIe motherboard, replacing the standard 64K-byte 80-column card, and supplies color output, additional RAM, and provision for battery-backed RAM. The card comes with 64K bytes and can be expanded to 1 megabyte of memory; you can add an optional 2 megabytes of static RAM, and with the company's MultiRam +, which plugs into the RGB card, you can add 3 more megabytes.

With the card, AppleWorks and other applications can be loaded entirely into RAM. Software supplied with the card lets you designate how much memory is to be used by programs. The hardware works with Apple ProDOS and DOS 3.3.

Checkmate points out that the card is compatible with exported IIe computers.

MultiRam sells for $199.95. Contact Checkmate Technology, 509 South Rockford Dr., Tempe, AZ 85281, (800) 325-7347; in Arizona (602) 966-5902.

Inquiry **560.**

Motherboard Upgrades XT to AT

CSS Laboratories has developed a motherboard that replaces the one in the IBM PC XT and upgrades that machine's memory, clock speed, and other functions to levels comparable to those of the PC AT. The XT-286, priced at $995, has a 16-bit 80286 processor, 512K bytes of memory (expandable to 4 megabytes with a card), 64K bytes of ROM, seven-channel direct memory access, and a real-time clock. The board also has a speaker.

Standard clock speed of the XT-286 is switch-selectable up to 8 MHz. The motherboard can be used with IBM PC-compatible peripherals and add-ons; it has three 8-bit slots and three 16-bit slots.

The XT-286 comes with a limited one-year warranty. For more information, contact CSS Laboratories Inc., 2134 South Ritchey St., Santa Ana, CA 92705, (714) 540-4141.

Inquiry **561.**

Utility Captures Screen Data for Use As Input

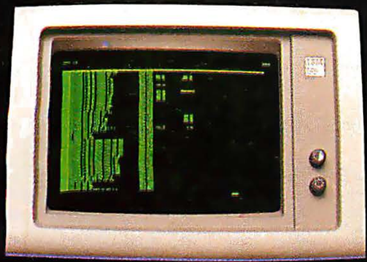
Your Move!, a memory-resident utility for IBM PCs and true compatibles, lets you take data directly from the screen for use as keyboard input. You can designate areas on the screen in which data is to be captured and kept in a RAM buffer or stored on disk for later. After invoking Your Move!, you can run your applications software; hitting a function key allows the captured data to be used as input in that program. A macro facility lets you store a sequence of Your Move! commands and execute them with one keystroke.

The utility carries a price tag of $59.95. For more information, contact Goldata Computer Services Inc., 2 Bryn Mawr Ave., Bryn Mawr, PA 19010, (800) 432-3267; in Pennsylvania, (215) 525-1036.

Inquiry **562.**

(continued on page 384)

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LOTUS 1-2-3 132 COLUMNS



PC PAINT



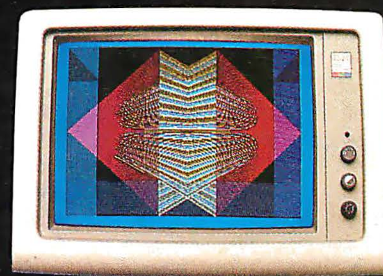
PC PAINTBRUSH 720x348



SYMPHONY HIGH RESOLUTION

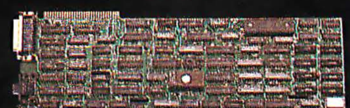


PC PAINT



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The Edge



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IBM Monochrome Compatible and High Resolution, 720x348 graphics	✓		✓		✓	✓
Runs Color Software on a Monochrome Monitor, Full Screen:	✓	✓	✓	✓		
—in 16 shades of green on the IBM Monochrome monitor	✓	✓	✓	✓		
—Runs Flight Simulator, PC Paintbrush, IBM BASICA commands and more	✓	✓	✓	✓		✓
—No patches or modifications needed	✓	✓	✓	✓		✓
—Displayed in the IBM standard 9x14 character set	✓	✓				✓
Extended Text Modes:	✓		✓			✓
—132 columns by 25 rows in monochrome	✓		✓			✓
—132 columns by 44 rows in monochrome	✓		✓			✓
—132 columns by 25 rows in color	✓		✓			
Runs Lotus 1-2-3™ and Symphony™ in high resolution monochrome graphics:	✓		✓		✓	✓
—in 132 columns by 25 rows	✓		✓			✓
—in 132 columns by 44 rows	✓		✓			✓
Runs Lotus 1-2-3™ and Symphony™ in High Resolution color:	✓		✓			
—16 colors, 320x200	✓		✓			
— 4 colors, 640x200	✓		✓			
Software switchable for all display modes and monitors	✓		✓			
Software switchable display memory, 16K, 32K and 64K	✓					
Disable Screen Memory	✓					
Printer Port (standard)	✓		✓	✓	✓	✓
Light Pen Connector (standard)	✓	✓	✓		✓	
Works in any PC-AT slot	✓	✓	✓	✓	✓	
List Price	$399	$395	$459	$395	$499	$680*

*Includes one serial port and clock/calendar.

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Conducted by Steve Ciarcia

MIRACULOUS MEMORY

Dear Steve,

While looking for memory to expand my TI-58 to 128K bytes, I came across a new type of chip called an EERPPROM. Can you explain to me how this memory device works?

PAUL JOHNSON
Knoxville, TN

The EERPPROM, which stands for electrically erasable retrievable past programmable read-only memory, is the newest development in memory. Not only can you write and erase the memory, you can also recover data that was erased up to one year before. This is accomplished by an internal comparator circuit that compares the stored charged level with an ideal logic 1 or 0, and by determining whether it is higher or lower, is able to find its previous logic state. —Steve

RETURN OF ONE JEDI

Dear Steve,

I had feared you were killed along with the rest of the COUNCIL when ALDERAN was destroyed. It is good to learn that most of the GUARDIANS of the OLD REPUBLIC have evaded the EMPIRE'S grasp and are continuing to educate the REBELS in the use of high technology for the good of all.

You have referred to LASERS in many of your past articles. Unfortunately, during my last duel my Model 91Q LIGHT SABER was slightly damaged. As you probably suspect, a LIGHT SABER's beam can create havoc if not restricted. Help me, Steve, you are my only hope. May The Force Be With You.

LUKE S.
A Galaxy Relatively Near

This was a common occurrence in 91Q LIGHT SABERS manufactured before the CLONE WARS. First a little background. The MICROSONIC TRANSDUCERS used in this model set up a standing wave at an adjustable distance from the LASER'S APERTURE. This causes the beam to be reflected back upon itself, restricting its length.

Due to the unbalanced nature of the DILITHIUM CRYSTALS used in the power source, the maximum differential input limits of the standing-wave exciters can be exceeded during high-use conditions like battle. Replacement of the TRANSDUCERS is mandatory unless peace is imminent. I also recommend that TRANSORBS (use TD50s) be Xeiallarced across the TRANSDUCERS to prevent recurrent failure.—Steve

OCCUPANCY DETECTION

Dear Steve,

I am a computer hacker interested in home-control systems. The problem I am having deals with developing a system for controlling lighting and heating based on room occupancy. I have tried many approaches, but all seem limited. Motion detectors can't see me in my favorite wingback chair. Infrared and heat detectors cannot pick up my wife, who has a slightly lower than normal body temperature. Acoustic sensors fail in my study, where I commonly relax by listening to music while wearing headphones (in order to avoid disturbing other household members).

The radio-transmitter pendant or amulet idea requires frequent battery changes, and they are still too big to wear as everyday casual attire. Have you come up against this? Is there any way to solve the problem without having to resort to multiple approaches?

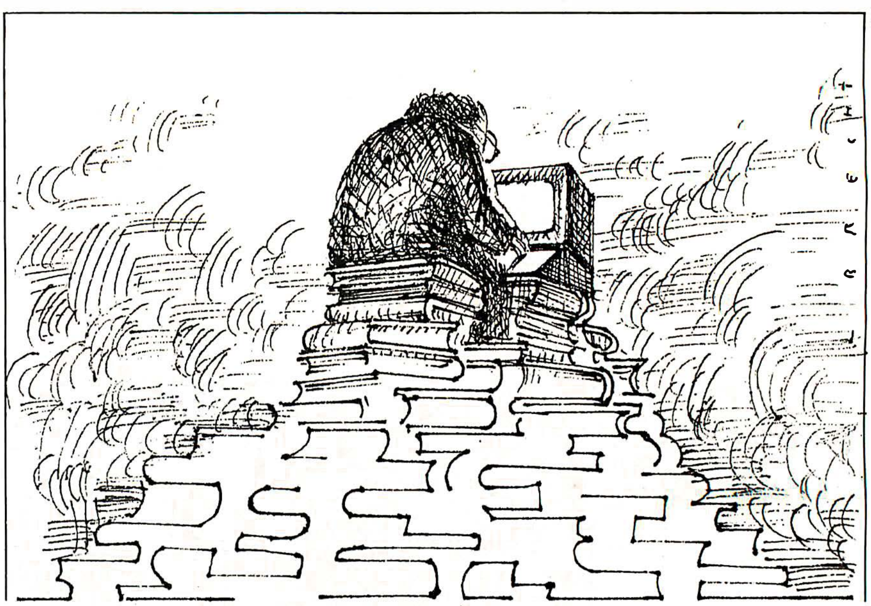
CHARLES RENKIN
Enrico, AZ

The main factor in the design of an occupancy-detection system is that it detect a physical phenomenon that is discrete enough to avoid false triggering yet require no special attention on the part of the person(s) in the room. Developers at Brookhaven Labs have come up with a unique way of tagging people and objects that satisfies both criteria. They employ radioactivity.

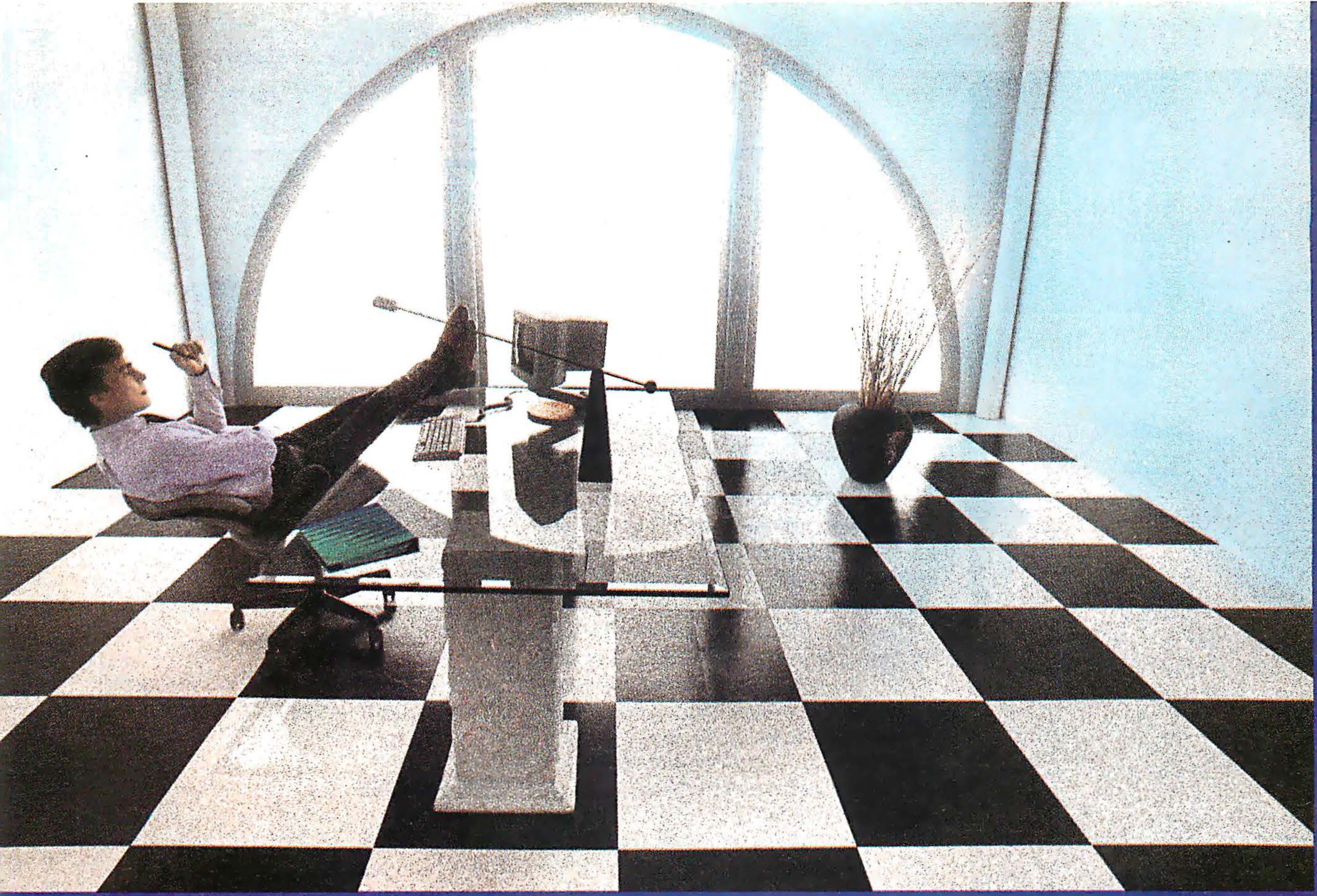
The system is quite simple. Persons, pets, or other objects you wish to have monitored are exposed to high but nonlethal doses of radiation from a radioactive source. Scintillation counters mounted in the various rooms detect the radioactive objects anytime they are in proximity.

The system's sensitivity can be improved by applying a few coats of lead-based paint to ceiling and walls, so as to shield various rooms from each other. The scintillation counters can be pur-

(continued)



ILLUSTRATED BY MACIEK ALBRECHT



chased as cold war surplus items. A doorway dosing unit for family and friends can be made from a lead-coated coffee can with a solenoid for opening the lid. The trigger for the solenoid can be run in parallel with your doorbell. A separate unit for each door is recommended for maximum efficiency.

Adding a computer to the system and using isotopes with differing specific levels of radiation would let you detect individual family members or pets as they move about the house.

The radioactive source can be obtained by contacting any mail-order scientific supply store, but some of the materials, especially the radium compounds, are expensive. An equally viable but more economical source is our interstate highway system, where you can follow trucks marked RADIOACTIVE WASTE and collect chunks of the material that fall or drip off.—Steve

A True Home Computer

Dear Steve,

I picked up a Cray-IS at a tag sale. It looked like it was in pretty good shape, but when I got it home and plugged it in, it didn't work. I think there must be a loose wire or something. This model was apparently an early prototype because there are almost no printed-circuit boards in it, just point-to-point wiring and a lot of funny-looking cubes with connectors on them. I have looked through all the back issues of BYTE and can't find anything on the Cray. Please send me any information you have as soon as possible. My wife says it is taking up too much space in the living room and has threatened to use it as a bench around the tree outside.

Ray C.
Boston, MA

One of the reasons it has become difficult to obtain information on the Cray-IS is that, like the VIC-20 and the Atari 400, it has been made obsolete by improved versions. For this reason, you won't see much software or many peripherals for it.

Many large corporations make information available to the general public and the KGB through a filing system called Dempster Dumpmaster. In most cases, those desiring information must do the research themselves at the facility, but 24-hour service is usually available for those for whom acquiring such information during normal business hours is inconvenient. You should be able to find a Dempster Dumpmaster file about the Cray-IS behind Cray's facilities in Minneapolis.—Steve

MXsfX. Modem

Dear S.eve,

I am usXng my modem .o send .hXs le..er .o .he Ask BY.E bulle.Xn board. As you can see, .here Xs a problem Xn my modem Xn.erface. Do you have any Xdeas on wha. s.eps I mXgh. .ake .o debug .he problem?

S.an SmX.h
Har.land, New BrunswXck, Canada

It looks like your modem is crossing the "i"s and dotting the "t"s.—Steve

Arctic Life

Dear Steve,

I have computerized my igloo using ideas from many of your articles ("Computerize a Home," "Computerize a Wood Stove," etc.) but have encountered several insurmountable, even very difficult, problems. The big problem is the heat. I added a steam pipe to my igloo, extending from the floor through the roof. This is a trick I saw my cousin use when I visited him. He lives in the Bronx (New York, of course). When it's too cold and you want more heat, you bang on the pipe.

Using information and ideas from your articles, I was easily able to rig a computer-controlled pipe banger, but there's still no heat. I've tried everything I can think of, but the system in my igloo doesn't function at all. Your assistance is greatly appreciated.

Vladimir Grosspiggian
Nome, AK

Your best bet is to move in with your cousin. And take the computerized pipe banger with you—your cousin will love it.—Steve

[*Editor's note: The following letter is a historic document. It was received by Steve in April 1975. I wonder what ever happened to these guys?*]

A Shoestring Operation

Dear Steve,

My friend and I are technicians for Hewlett-Packard and Atari and are very interested in designing a computer system. Although we have designed some stuff (blue boxes, etc.), we have never tackled a project as ambitious as this. We decided to use the 6502 processor because we got one pretty cheaply and just can't afford

(continued)

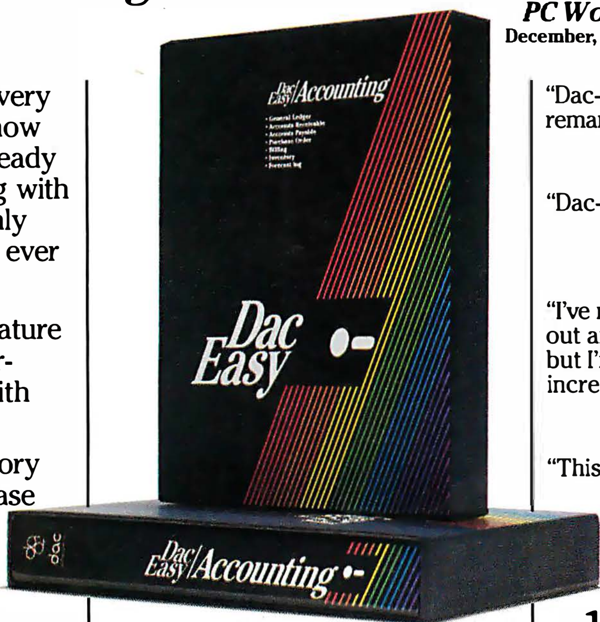
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[1]Trademarks of International Business Machines Corp.
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a good processor like a Z80 on our salaries! What we had in mind was an S-100 card with the 6502 and 16K bytes of RAM, all on one card! Pretty neat idea, huh? We figure that no one will ever need more than 16K bytes of memory—what would you do with it? We thought that we'd include some sort of ROM monitor function, too. Then you just add a serial port for a standard video terminal and maybe a Tarbell cassette interface.

Do you have any suggestions for us?

STEVE J. AND STEVE W.
Applegate, CA

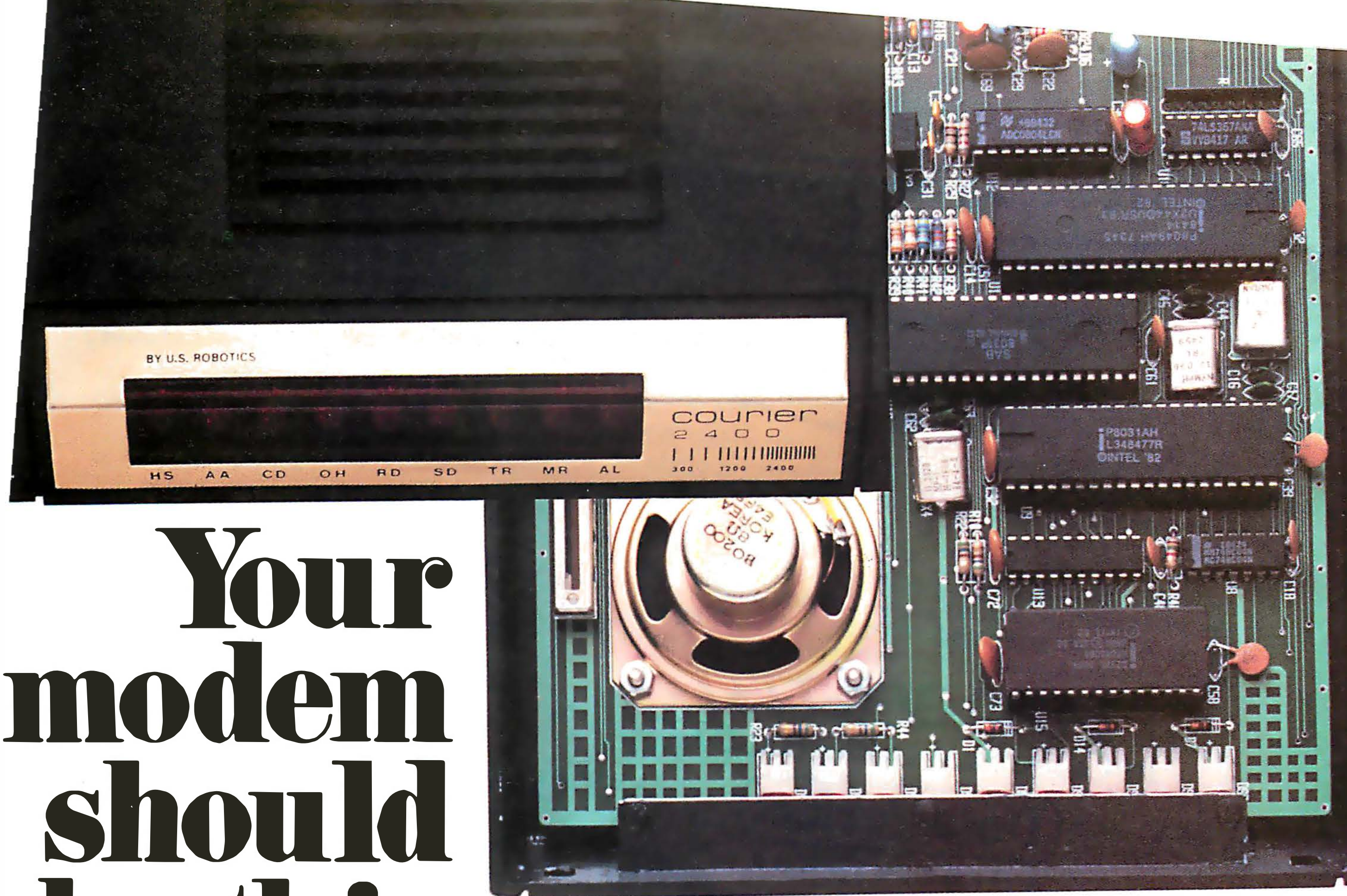
You guys are heading in the right direction by wanting to include multiple functions on one card, but why not take the idea "to the max," as you say in California. Why not put the processor, memory, I/O, and mass-storage interface all on one board? I bet you could add some circuitry to use a TV set for video I/O. Make it a color set while you're at it; the bandwidth will be limited, but you could limit it to uppercase and just 40 characters per line, and you could add a separate color-graphics mode, too. I could see a single-board computer packaged in a neat little case with a high-efficiency switching power supply and keyboard built in; the TV monitor could sit on top, with your cassette recorder right beside it.

But whatever you do, please make sure it has some sort of expansion capabilities. Why not bring out seven or eight expansion slots in the rear with the address lines already decoded? And 16K bytes of RAM may seem like a lot, but eventually even 64K bytes won't be enough. And though they are expensive now, I'd be willing to wager that people will want to add floppy disks for true random-access storage. (I was just suggesting to Al Shugart last week that he should make something more compact than those 8-inch drives of his.)

And don't forget software. ROM monitors may be okay for us hackers, but if you are going to get more people interested in this machine of yours, you will have to supply them with a higher-level language like BASIC.

If you guys play your cards right, you could turn your little computer into a true home "appliance." But if you ever hope to sell more than a few hundred, you will have to make it real easy to use. And do it now, before the Japanese decide to do it. In the near future, a home computer should be as American as mom's apple pie.

(continued)



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Most public databases and bulletin board sys-ems now offer 2400-bps service. In fact, more han a thousand bulletin board operators have hosen our Courier 2400—a demanding applica-ion that has proven the Courier's reliability and fficiency.



Lawrence and Lee, playwrights ("Inherit the Wind," "Auntie Mame," "First Monday in October," and many other Broadway hits, motion pictures and teleplays) **and educators** (professors of Advanced Playwriting at UCLA and USC).

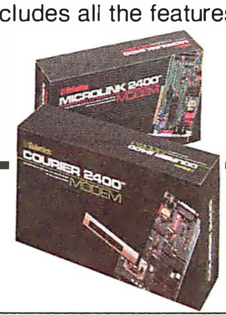
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PERSONAL USE ☐ BUSINESS USE ☐

Good luck with your project. Let me know how it turns out.—Steve

[Editor's note: The truth is stranger than fiction it is said, and this last letter for the April column is one actually received by Steve Ciarcia.]

EXOCHRONIC INSTABILITY

Dear Steve,

I read with interest your response to Sean F. McCartney in the September 1985 Ask BYTE in which you suggest an endochronic transmission line to solve time-delay problems in Mr. McCartney's starship. You cited the Good Doctor's seminal work with thiotimoline but curiously failed to mention the fact that many semiconducting materials in common use today exhibit temporal instability. Anyone who has tried to debug a VLSI chip will have many tales of signals that arrive at point B before having left point A. The trouble with temporal instability is that it's, ah, unstable. This is especially true of endochronic instability. Frequently, the signal that arrives at B isn't the same shape as the one that left (will have left!) A. Once we understand endochronic instability, we'll be on the way to such goodies as sensors that detect events that haven't happened and laser cannons that shoot intruders who aren't there.

What we need is a beginning point for our research. I suggest exochronic instability as that beginning point. Exochronic instability is often far more stable than endochronic instability. It's relatively easy to build circuits in which a signal leaves A and is never seen again. This can be done with ordinary conductors, as well as with semiconductors, and at scales far larger than VLSI. Can you explain why this important topic is not already a national priority?

BOB BROWN ■

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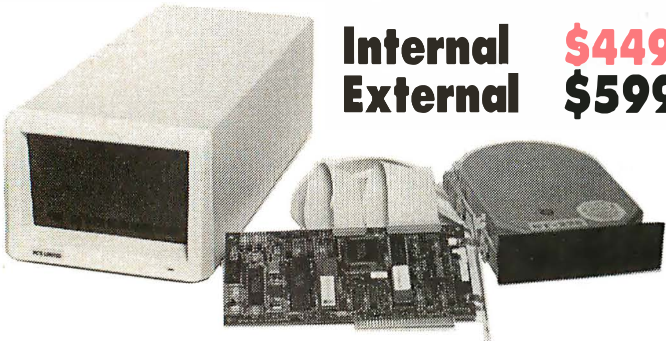
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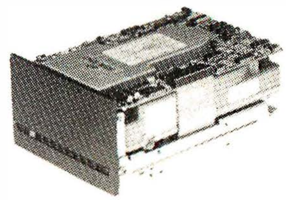
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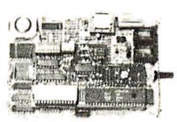
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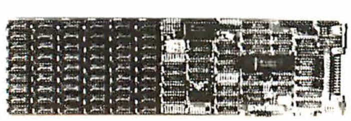
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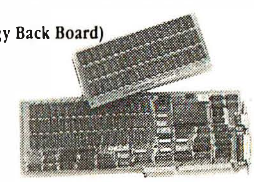
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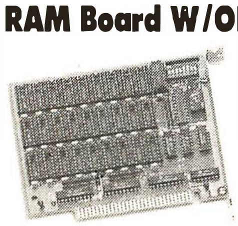


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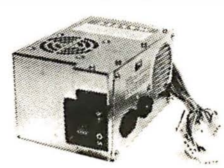
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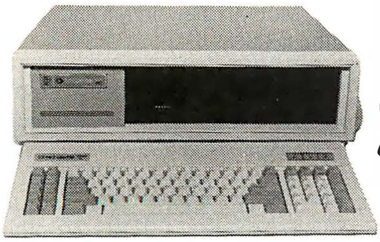
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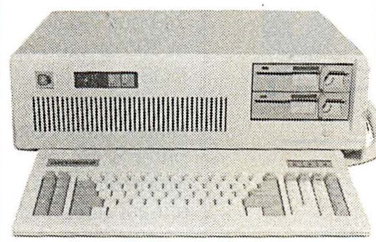
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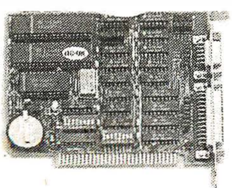
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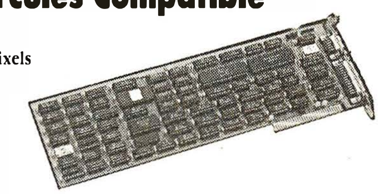


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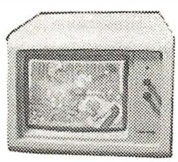
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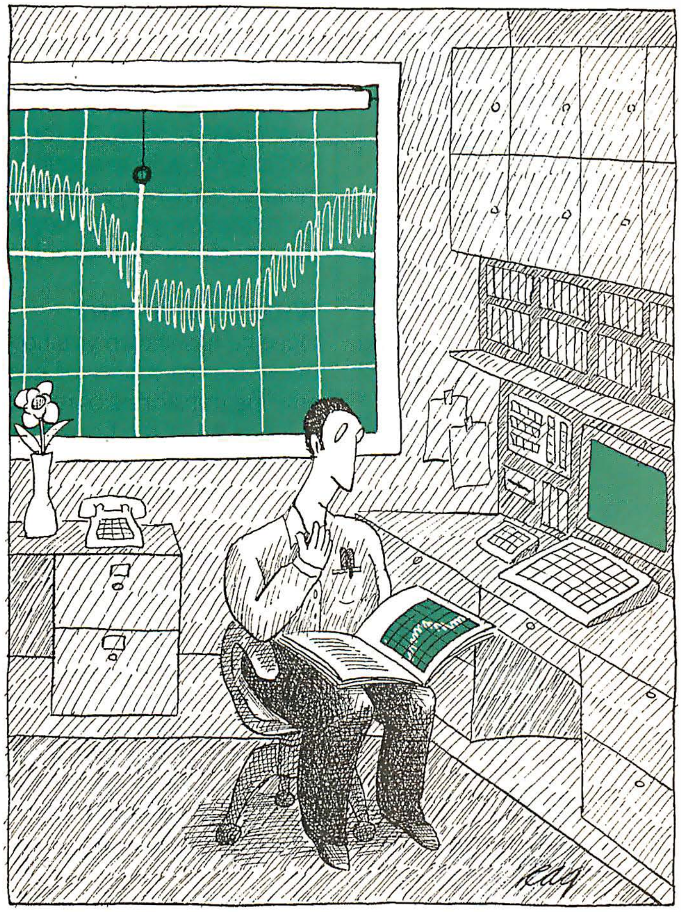
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THE FFT: FUNDAMENTALS AND CONCEPTS

Reviewed by Thomas R. Clune

The fast Fourier transform (FFT) has become ubiquitous in scientific and engineering instrumentation. As a result, many more people have to work with it than have to program FFT routines. Most books that cover the FFT discuss its derivation and alternate ways of implementing the algorithm. What we need is a discussion of the practicalities of working with FFT instrumentation. Robert W. Ramirez's fine little book, *The FFT: Fundamentals and Concepts*, is just such a volume.

Ramirez is an employee of Tektronix Inc., the oscilloscope company, and it shows. The book reads like it was written by someone who has spent a lot of time in customer support with technicians, engineers, and scientists. Ramirez does not belabor what is "theoretically interesting" but concentrates on what is practically important.

The book is divided into three parts: a general introduction to Fourier analysis, a specific discussion of the FFT and how to use it, and a presentation of the Sande-Tukey algorithm (decimation in frequency) and a BASIC program to implement it.

The first part is closest in style and content to the usual books on the Fourier transform. It presents a (thankfully, nonrigorous) derivation of the Fourier integral from the series, discusses interpretation of polar and rectangular forms of a transform, explains the effects of scaling and shifting in one domain on the transformed spectra, and introduces the notions of even, odd, and mixed functions of time.

Although the treatment of these topics is as clear and conceptually appealing as such material is likely to get, I would not have been offended if the treatment had been shortened by a factor of four. In truth, I would have been perfectly content for the book to begin with the discrete Fourier transform (DFT). Depending on your needs and interests, you may want to just scan the first three chapters and begin reading in earnest at chapter 4.

THE DFT

Part 2 begins by introducing the DFT and includes a simple, slow BASIC program to implement it. The main virtue of the program Ramirez presents here is that it is clear. Anyone with any hope of understanding a DFT should be

(continued)

ILLUSTRATED BY RICHARD A. GOLDBERG

able to figure it out from the eight lines of code that implement the algorithm. The program also allows the author to introduce the topic of data output formats for DFTs and FFTs.

Since an FFT is just a DFT that executes quickly, Ramirez uses the DFT as the basic introduction to the FFT. In part 3, he returns to the FFT and provides a detailed look at how it works, but he is wise not to bog down his discussion of working with the FFT with unnecessary implementation details.

One of the most appealing aspects of this book is that it is peppered with photographs of oscilloscopic displays of waveforms and their transforms in either real/imaginary format, magnitude/continuous-phase format, or magnitude/phase modulo 2π format. The value of this approach is that you begin to acquire experience in interpreting FFT information. Given a series of waveform displays and transform displays, you can begin forming expectations of what the transform of a waveform should look like.

What's Important

Once he has shown you how to read a transform, Ramirez discusses the reality of even and odd harmonics by examining transforms of real square waves. The photographs in figure 6-1 of the book make it very plain that easily overlooked differences in DC offset can have very pronounced effects on the appearance of the transform. This is important to know if you're going to work with FFTs, and it's just the kind of information you usually have to pick up the hard way. Ramirez continues with a discussion of noise, both that in the signal and that introduced by the conversion instrumentation, and what you can do about it. He then discusses leakage. While there is nothing revelatory in his treatment of these topics, they are important and should be covered. And in keeping with Ramirez's emphasis on what is important rather than what is interesting, he is not above explicitly pointing out that the assumed periodicity of the FFT refers to the sampling window, not the waveform.

Aliasing

The discussion of windowing and sampling leads naturally into aliasing. Ramirez begins by stating the Nyquist theorem, without proof (thank you). He then goes on to show what oscilloscopic displays of the frequency-magnitude transform look like as you approach the Nyquist limit, and he suggests, reasonably enough, that you try to use a sampling rate at least three times the frequency of the fastest component of your data. Beyond the pictures, there is little in this that exceeds a usual competent treatment of aliasing. However, Ramirez continues on from here. He discusses what the frequency transform looks like when you exceed the Nyquist limit and why. The treatment is divided into two parts: what aliasing looks like when you exceed the Nyquist limit by only a little, and what happens with massive aliasing. This is important. If

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you are going to analyze transformed data successfully, you have to be able to recognize aliasing when you see it—and you will see it. Ramirez's treatment of this topic is by far the most useful I have seen.

After examining potential problems with FFTs, Ramirez offers guidelines for improving FFT results. His discussion includes signal averaging, subtracting DC bias, pointing out that phase components are meaningful only where frequency components exist, discussing phase delay, the trade-off between time-domain resolution and frequency-domain resolution in selecting sampling rates, and the shape, roll-off, bandwidth, and effects on frequency-domain magnitude of different windows. This last topic is presented especially well and includes oscilloscopic displays of the results of using different windows on an almost periodic waveform.

Some Applications

Ramirez closes part 2 with a very brief look at FFT applications. Included are distortion analysis, signature analysis, transfer functions, convolution and deconvolution, and correlation analysis. The author's discussion of each is so brief that it includes little more than a definition of terms. I would have preferred to have this chapter expanded by the factor of four that part 1 could have been pruned by. Nonetheless, the discussion is useful in providing some idea of what you can get out of Fourier analysis.

Part 3 of the book is devoted to a clear discussion of the Sande-Tukey algorithm. It includes a BASIC program that implements the algorithm and lacks only input and output routines to use. Though the book ends with a bibliography for further study, don't expect the referenced books to be as clear and informative as this one.

The FFT: Fundamentals and Concepts was written for people who work for a living. If you are about to acquire an FFT instrument or have to bring new employees up to speed on working with FFT instrumentation, you will want to have this book around.

DESIGNING DIGITAL FILTERS

Reviewed by Thomas R. Clune

Designing Digital Filters is an undergraduate textbook in digital filtering. It assumes that the reader neither knows what a filter is nor how to make one. Anyone who believes that it is desirable not to make assumptions will be cured of that view by reading this book.

The author begins by asking the question, "What is a filter?" The answer: "In the most general terms, a filter is a *black box* with a set of inputs and a set of outputs. The box contains some form of processing that generates the outputs from the inputs." In case anyone fails to recognize that this definition can encompass anything from a bowling alley to a notch filter, the author follows it with an example showing that a cash register is a filter.

(continued)

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Early on in his exposition, Charles Williams presents a noisy EKG as an example of data needing filtering, then provides (without explanation) a simple weighted moving-average filter to improve the output. He then notes, "For reasons probably unknown to you, this filter attenuates the muscle noise without greatly affecting the EKG signal." In not much more space than that, he could have offered some insight into what is going on. But the full thrust of this book is to place mathematical rigor above insight.

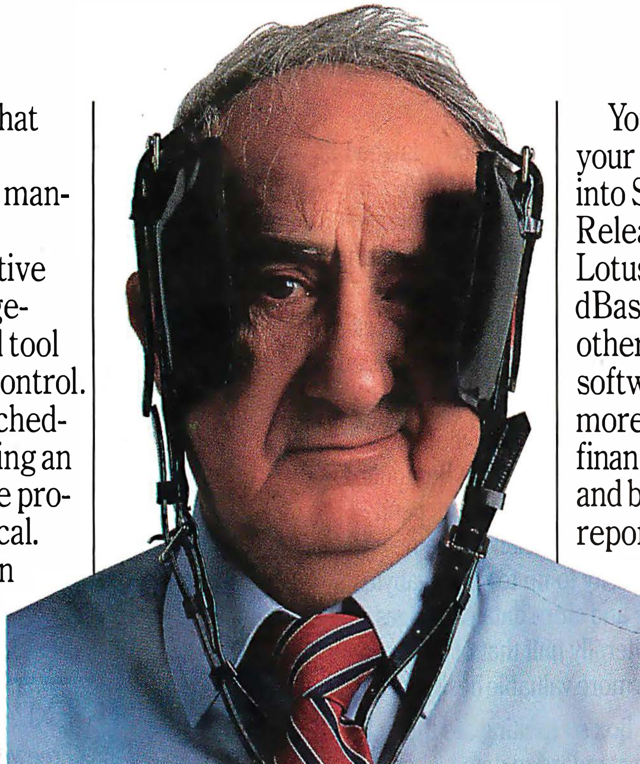
In keeping with this theoretical emphasis, Williams derives the Nyquist limit before getting out of the first chapter. He then notes that, for any signal that is represented as the weighted sum of sines and cosines, exceeding the Nyquist limit will result in aliasing. This kind of exposition bothers me for several reasons. First, most people would be better served by the more insightful treatment of aliasing provided by Ramirez in *The FFT* (see the preceding review). Second, it is very easy for neophytes to gloss over the "weighted sums of sines and cosines" part of his point. Most smoothing techniques used on data are more likely to produce garbage than aliasing if pushed too far. Further, most will produce garbage long before the Nyquist limit is reached. Consider, for example, a moving-average smoothing algorithm. This criticism may seem unfair. But most popular articles I have seen (including some in BYTE) hold up the Nyquist limit as some universally applicable speed limit for sampling rates without regard to the method of analysis. This is just the sort of confusion that a course in filtering should set to rest, but this book makes it all too easy for students to be reinforced in their ignorance. Finally, the hardest question to answer with respect to the Nyquist limit concerns the highest frequency component important to a given data set. Unless you are dealing only with pure sine waves, the answer to this question is very obscure. But you will get little help from this book in analyzing your data to determine its filtering requirements.

The author's discussion of convolution and windowing is rather well done, but it could benefit from a more thoroughly graphic presentation. Nonetheless, his treatment of Hamming windows and Kaiser windows is one of the best parts of the book. Similarly, when he returns to this topic while discussing the discrete Fourier transform, his exposition of the trade-offs between narrowing the main lobe and attenuating the side lobes for a window is clear and useful. His illustration of the effects of uniform and Hamming windows on the same data and his warning that you must know the window to know how to interpret the transform are well done and cogent. For me, however, these passages only served to highlight the lack of such cogency in the rest of the text.

The discussion of polynomial modeling of digital signals, for example, does not maintain the quality of exposition Williams attained with windowing. After presenting the general equations for fitting polynomials of a given order to a set of points, Williams discusses estimating missing

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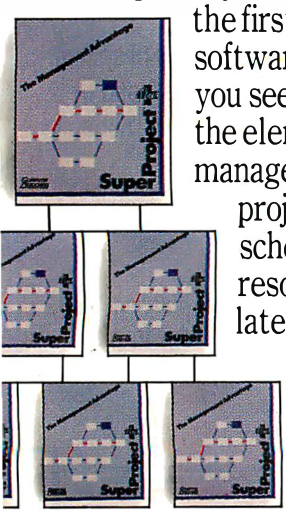
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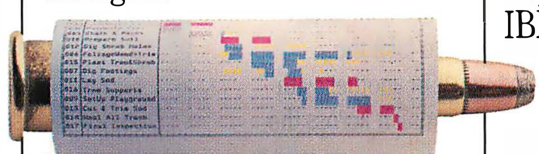
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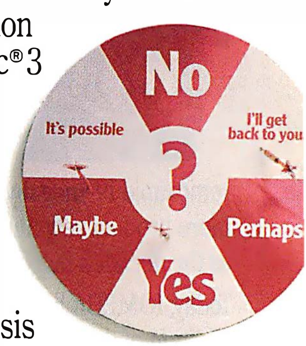


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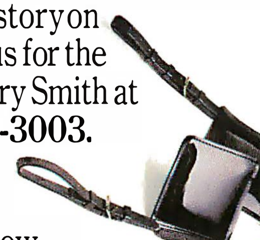
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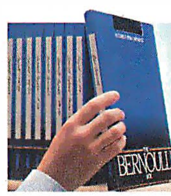
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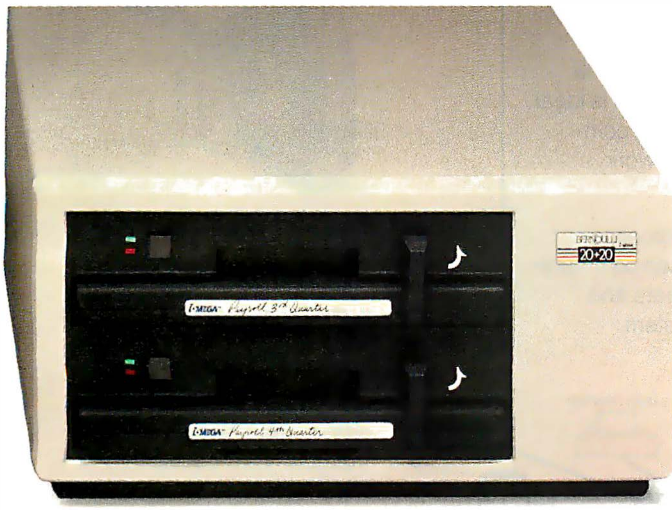


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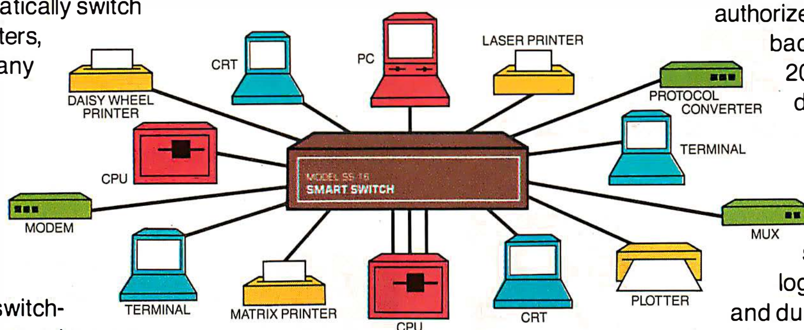
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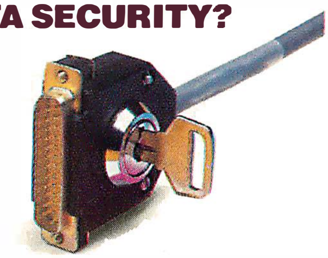
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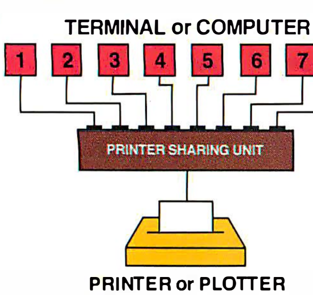
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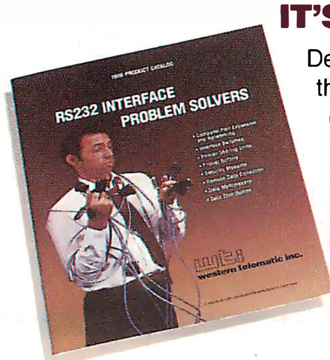


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data points as follows: "Most of us would just 'eyeball' the data so that the estimates 'look right.' However, polynomial modeling provides us with a formal, rigorous approach to data estimation." I shudder to imagine how many students draw the conclusion that "formal, rigorous" fitting of data offers an improvement over eyeballing. Indeed, the entire treatment of polynomial fitting gives very short shrift to overfitting data. While Williams does indicate that real data contains noise, he acts as though a least-squares approach will deal with the problem. In fact, selecting an appropriate order polynomial for a given data set is a very difficult problem. It requires having some understanding of the basic form of the data or some appreciation of the level of precision that can be associated with a given data set. It is most certainly not a mechanical process, and your surest guide to avoiding rigorous foolishness is "eyeballing." But this is just another way of saying that you can't teach people with no understanding of what they are trying to do how to do it.

The book ends with a couple of surprisingly good appendixes and a list of references. I only wish that the spirit that guided the writing of the appendixes had guided the writing of the book itself.

Before coming to BYTE, *Thomas R. Clune was the Physical Chemistry Laboratory Coordinator at Brandeis University, where he taught computerized data acquisition for chemistry and computer science students. He can be reached at* BYTE, *POB 372, Hancock, NH 03449.*

MACINTOSH REVEALED, VOLUME TWO: PROGRAMMING WITH THE TOOLBOX

Reviewed by Bonnie L. Walker

Programming with the Toolbox picks up where *Volume One: Unlocking the Toolbox* left off, as Stephen Chernicoff continues his effort to unravel the mysteries of the Macintosh's powerful user interface, the Toolbox (for a review of Volume One, see November 1985, page 57). The two-volume *Macintosh Revealed* is intended for serious programmers who plan to develop applications using either a Pascal compiler or 68000 assembly language. Chernicoff assumes a fairly high level of programming experience but assumes very little background with a Macintosh. Examples throughout both volumes are in Lisa Pascal and 68000 assembly language. From time to time this approach results in an uneven style, as the author goes into detail about Mac philosophy on one hand and skims over highly technical points related to programming in these languages on the other.

MINIEDIT: A SAMPLE PROGRAM

The most important feature of *Unlocking the Toolbox* is the sample program MiniEdit, which was developed using Lisa Pascal. MiniEdit is a simple interactive text editor that demonstrates many of the features of the Toolbox and

(continued)

provides a framework for developing your own application program. Throughout the book small sections of MiniEdit are presented and explained. MiniEdit includes Toolbox routines that control events, windows, menus, controls (buttons, dials, scroll bars), cut-and-paste text editing, alert and dialog boxes, and disk I/O. (The complete source code, which is 45 pages long, is included as an appendix. It is also available from the Hayden Book Company for $19.95 plus $2.50 postage and handling.)

In Volume Two, Chernicoff has attempted to write a tutorial about the Toolbox for people who are already experienced with Pascal or 68000 assembly language. While the focus is on the technical knowledge needed to access the built-in routines that make a Macintosh program unique, the text is interwoven with Macintosh philosophy. For instance, the author points out that the Macintosh is dedicated to the principle that the user, not the computer, should be in control. On a Macintosh, a user controls the program by clicking the mouse or typing on the keyboard. Each user action is an "event" to which the program must respond.

Each chapter addresses one aspect of the Toolbox, illustrated by parts of MiniEdit and then explained in depth. A reference section after each chapter restates the procedures in both Pascal and assembly language.

Ordinarily in books of this type, sample programs are given so that they can be entered at a computer, run, and modified as learning experiences. This is not the case with the example procedures throughout this book. Due to the nature of Pascal and the complexity of MiniEdit, the examples are "shells" that are presented as a focus for the tutorials, to be studied and understood as "tools" for developing an actual program.

PASCAL COMPILER FOR THE MACINTOSH

In Volume One, Chernicoff warned that since MiniEdit was compiled on a Lisa, a few changes might be required when the program was used with the Macintosh Pascal compiler. Unfortunately, a Macintosh Pascal compiler was not available from Apple as I reviewed this book. Since MiniEdit is a major component of Volume Two, the book is far less useful than it could be. Translating MiniEdit so that it will run on the interpreted version of Macintosh Pascal is impractical because of this particular implementation's limitations. (I should mention that Chernicoff does not refer to the interpreted Macintosh Pascal in the book. Perhaps he assumed that either a Macintosh Pascal compiler would be available or that the reader would be using a Lisa or Macintosh XL.) A UCSD Pascal compiler and development system for the Macintosh are available from SofTech Microsystems (San Diego, CA).

TEXTEDIT REVEALED

Programming with the Toolbox provides a great deal of information about TextEdit, the text-editing facilities in the Toolbox that are comparable to QuickDraw, the graphics

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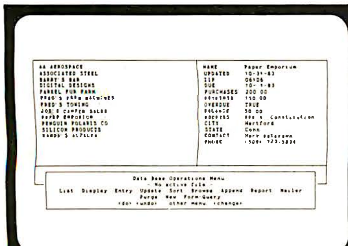
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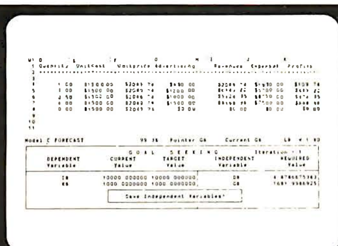
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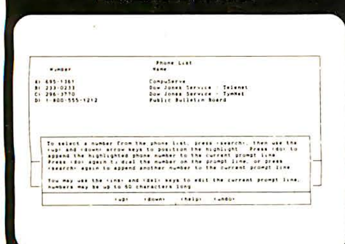
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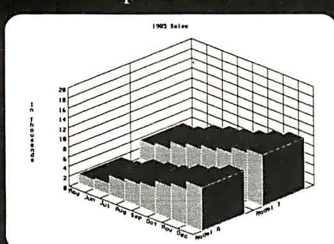
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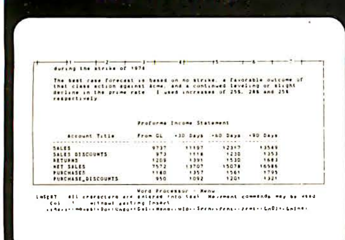
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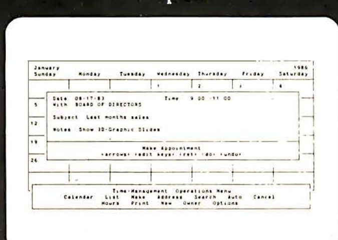
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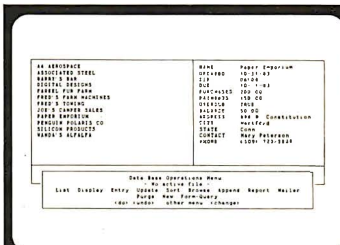
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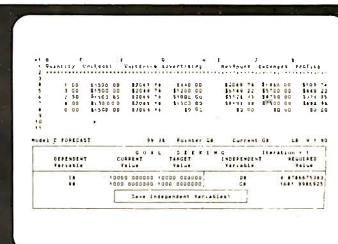
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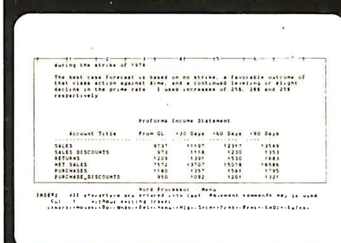
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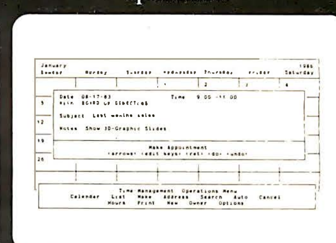
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facilities. For example, TextEdit provides automatic word wrap, with any sequence of non-space characters defined as a word. Text is automatically wrapped after a cut, paste, or type-in. There are built-in routines for all standard cut-and-paste editing. Chernicoff also identifies some of the features that are *not* built in, such as Undo and automatic scrolling. MiniEdit includes the code for automatic scrolling, but you'll have to figure out Undo for yourself, since MiniEdit does not include procedures for that feature.

MAC FILE MANAGEMENT

The discussion of file management (I/O) provides some information applicable in day-to-day use of the Mac. A great deal of information is included about the Macintosh's built-in disk drive and how to create and use files. Chernicoff also explains how to use two of the standard packages in the system resource file, the Standard File Package (MiniFinder) and the Disk Initialization Package.

NOT THE BASIC REFERENCE

Macintosh Revealed, Volume Two: Programming with the Toolbox provides a combination tutorial and reference for developing a Macintosh application program. Unfortunately, despite its length (well over 1000 pages in the combined volumes), you'll still need the basic Macintosh reference, Apple's *Inside Macintosh*. *Programming with the Toolbox* does not include routines for using the printer and in many cases refers the reader to *Inside Macintosh* for more information. Of course, you will also need either Pascal or 68000 assembly-language reference books (and expertise) as well.

Bonnie L. Walker is Project Director of JWK International (7617 Little River Turnpike, Annandale, VA 22003), *a systems analyst/programmer, and a technical writer.*

EXPLORING THE PICK OPERATING SYSTEM
Reviewed by Larry Allen Heberlein

Exploring the Pick Operating System by Jonathan Sisk and Steve VanArsdale may well be the first book on the Pick operating system, even though Pick has been in use by businesses for a decade. A multiuser system for managing databases, it's available on a score of machines, including half a dozen implementations on the Motorola 68000. Recent releases of versions for the IBM PC XT and AT and the warm reception of the Pick clone Revelation have helped it along. (For an overview, see Parts 1 and 2 of Rick Cook and John Brandon's "The Pick Operating System," October and November 1984 BYTE. For a review of the PC version, see "Pick, Coherent, and THEOS" by Marc J. Rochkind, BYTE's *Inside the* IBM PCs, Fall 1985.)

TECHNIQUES

Unfortunately, this book is a disappointment. Stingy with examples but filled with unnecessary detail, lacking

(continued)

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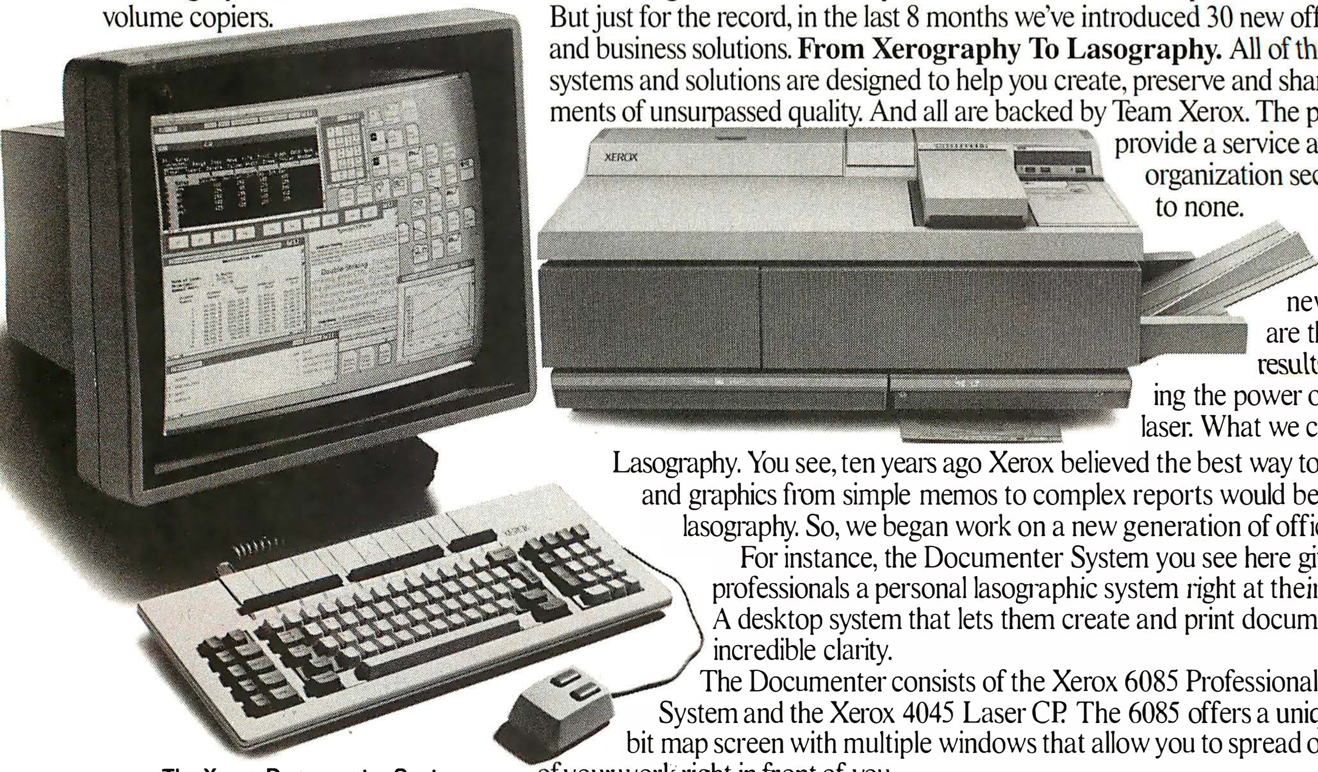
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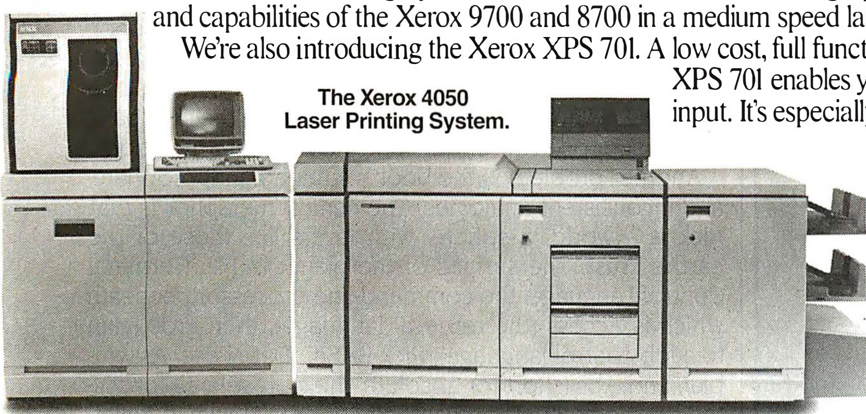
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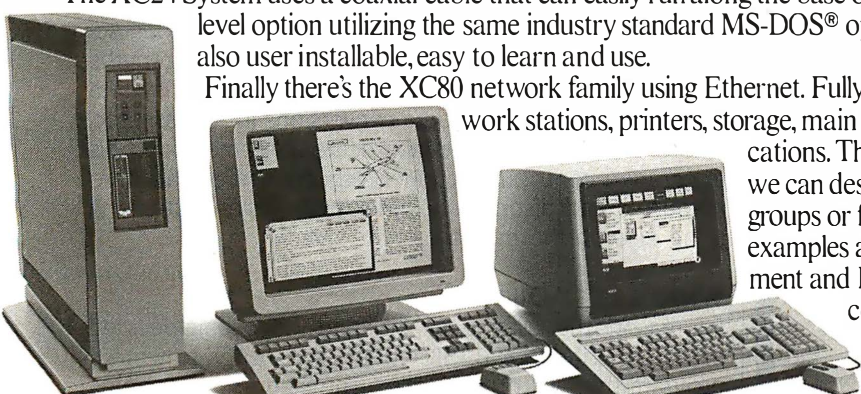
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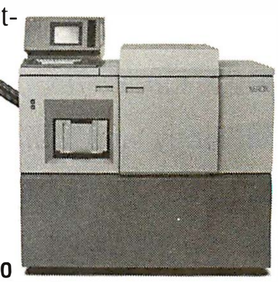
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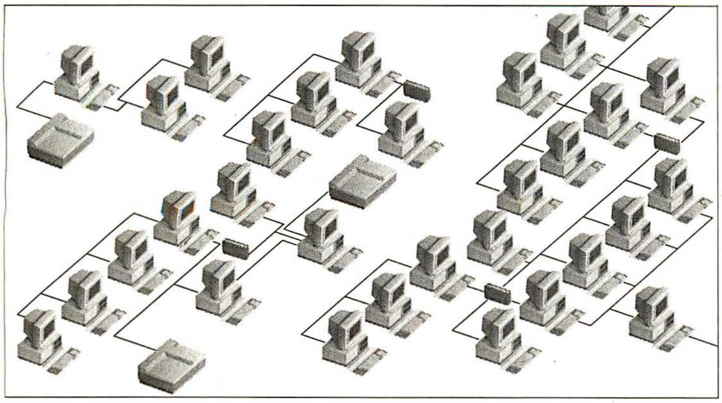
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technical meat but replete with insider jargon, the book seems to have been put together without any clear conception of its audience. On one page the authors assume you have never touched a keyboard, and on the next page you're supposed to understand hexadecimal notation.

Another problem is the book's strained, inappropriate, and inconsistent analogies. The central metaphor is that Pick is a world, a sphere, with layers like those of the earth's crust. The surface of the planet is TCL (Terminal Cont ol Language, the command-line processor), beneath which is Access (the retrieval language), then Proc (akin to a job control language), Pick BASIC, Data Base, Assembler, and Abs (short for absolute, the storage area for systems programs). These categories aren't even parallel. Most of the "levels" are languages, Data Base is all the files on the computer, and Abs is just a place where some things are kept.

The metaphor itself is inaccurate. The processors listed do *not* form a hierarchy. Proc, for example, does not have to go through BASIC to get to the database, nor does Access have to go through Proc. It is one of the strengths of the system that the languages use the same system routines. File updates or data conversions in Access, Proc, BASIC, or even Assembler all execute the same code. This integration contributes to Pick's thrifty use of hardware resources and distinguishes Pick from just about everything else on the market.

What's Left Out

For reasons that escape me, Sisk and VanArsdale decided not to describe Pick BASIC—not even enough to write a program that will print "Hello." The standard that holds Pick implementations—and Pick clones—together is Pick BASIC, a language with a rich set of functions for manipulating the Pick database.

The book lacks a sense of balance. The bias of the authors is that the Pick operating system is revolutionary, a breakthrough, a window into a new era; that its users are sophisticated, artistic, gaining in productivity "while acquiring a new zeal and enthusiasm." Nowhere do the authors attempt to appraise Pick critically.

One advantage of the system is its use of dictionaries to describe the structure of a file. On the simplest level, I can use a dictionary to name a field in all the records in a file (e.g., the third field of all employee records will be named "Salary") and access the fields by name in a remarkably conversational retrieval language ("Sort Personnel by Salary").

More significantly, my dictionary can specify conversions to be performed as data is being retrieved. I can specify concatenation, extraction, range checking, or formatting. I can use the field as a search key for translation through another file. I can request that all sorts of math be done on the field before or after sorting it. For example, my dictionary could define "Take.Home.Pay" as weekly pay minus deductions and even explain how to figure the deductions,

(continued)

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looking up my tax bracket in another file. The advantage here is the concept of virtual data—from the command line a user can list and sort data that doesn't exist until it's asked for. The authors explain the physical format of a dictionary item, but they don't communicate a sense of the power of dictionaries. Nor do they convey a sense of how the system's features could actually be used. The examples are not only sparse but also lifeless and abstract.

Unfortunately, the authors didn't take the time to compare Pick to more conventional and more familiar systems, either by way of explaining Pick or to help potential users decide what might be appropriate for their needs. (A comparison shopper might, for example, like to know how Pick and other systems handle the problem of multiple users trying to update the same record at the same time; this topic isn't mentioned.)

And they don't compare Pick systems with each other. Pick systems are not all alike. Some will let you execute TCL commands from inside a BASIC program. Some will let you retrieve and edit previous TCL commands. Various implementations call things by different names. In fact, the original implementation and the biggest seller calls things by different names than those used here, and the things act differently than described here.

THE GOOD POINTS

The index is copious and accurate. There is an excellent glossary of Pick terms. The typography and layout are well done, and the book is remarkably free of grammatical and typographical errors.

The authors know whereof they speak. The senior author is head of a large Pick training agency and author of the pocket reference guides Pick Systems publishes. Although the explanations might occasionally confuse (such as a sentence that appears to imply that a group is the same thing as a frame), if you can understand what is being said, you can be sure that it is technically accurate.

CONCLUSION

Pick is justly praised for its ease of use. Applications are easy to create in the programming environment, and the database is easy to access. User magazines are full of testimonials from executives that "at my last company, if I wanted a report I'd have to wait weeks until the data processing department could generate it; with Pick, I can get it myself in minutes." But ease of use is relative, and "Pick" isn't short for "point and click." It's a command-line environment, and to use it you have to learn the commands. Anyone who can master the command line of CP/M or MS-DOS could master Pick quickly. A book of this length could easily be produced that would teach novices everything they need to know in a few sessions. That book would serve a wide market, but this isn't that book. ■

A software engineer at CDI Information Systems, *Larry Allen Heberlein* (4132 Corliss N, Seattle, WA 98103) *maintains the Pick operating system on the* IBM Series/1.

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ELEVENTH WEST COAST COMPUTER FAIRE, Moscone Center, San Francisco, CA. Computer Faire Inc., 181 Wells Ave., Newton, MA 02159, (617) 965-8350. *April* 3–6

FEDERAL OFFICE SYSTEMS EXPO (FOSE '86), Washington Convention Center, Washington, DC. National Trade Productions Inc., 2111 Eisenhower Ave., Suite 400, Alexandria, VA 22314. *April* 7–10

IEEE INFOCOM–86, Miami, FL. IEEE Computer Society, 1109 Spring St., Suite 300, Silver Spring, MD 20901, (301) 589-8142. *April* 7–10

1986 IEEE INTERNATIONAL CONFERENCE ON ROBOTICS AND AUTOMATION, San Francisco, CA. Robotics and Automation, c/o Harry Hayman, 738 Whitaker Terrace, Silver Spring, MD 20901, (301) 434-1990. *April* 7–10

1986 TEST & MEASUREMENT WORLD EXPO, San Jose Convention Center, San Jose, CA. Meg Bowen, Test & Measurement World Expo, 199 Wells Ave., Newton, MA 02159, (617) 964-8900. *April* 8–10

WESTERN REGIONAL COMPUTER TECHNOLOGY FOR THE HANDICAPPED, Los Angeles Convention Center, Los Angeles, CA. Closing the Gap, POB 68, Henderson, MN 56044, (612) 248-3294 or (507) 345-8233. *April* 9–13

ALASKA ASSOCIATION FOR COMPUTERS IN EDUCATION '86: FORGING THE LINK BETWEEN COMPUTERS AND CURRICULUM, Anchorage, AK. Dennis Daggett, Kenai Peninsula Borough School District, 148 North Binkley, Soldotna, AK 99669, (907) 262-5846. *April* 10–12

INTERVENTION STRATEGIES FOR THE NONSPEAKING, Children's Hospital of Philadelphia, Philadelphia, PA. Ann Campbell, Children's Seashore House, Communication Technology Center, 4100 Atlantic Ave., Atlantic City, NJ 08404, (609) 345-5191. *April* 11–12

NINETEENTH ANNUAL SMALL COLLEGE COMPUTING SYMPOSIUM, Rapid City, SD. Dale Rognlie, Mathematics and Computer Science Department, South Dakota School of Mines and Technology, Rapid City, SD 57701, (605) 394-2470. *April* 11–12

CHI '86: CONFERENCE ON HUMAN FACTORS IN COMPUTING SYSTEMS, Boston, MA. ACM Conference Management, 11 West 42nd St., New York, NY 10036, (212) 869-7440. *April* 13–17

AIM FIFTH ANNUAL CONFERENCE: INFORMATION MANAGEMENT IS EVERYBODY'S BUSINESS, Boston, MA. Associated Information Managers, 1776 East Jefferson St., 4th Floor, Rockville, MD 20852, (301) 231-7447. *April* 15–16

COMPUTER GRAPHICS NEW YORK '86, New York, NY. Andry Montgomery and Associates, 8300 Greensboro Dr., Suite 690, McLean, VA 22102, (703) 893-4545. *April* 15–17

WHAT CURRICULUM FOR THE INFORMATION AGE? New York, NY. Office of Continuing Education, Box 132, Teachers College, Columbia University, New York, NY 10027, (212) 678-3064. *April* 17

MICROCOMPUTER JUNGLE: IMPACT ON HEALTH CARE, Overland Park, KS. Carole Rosen, University of Kansas Medical Center, Office of Continuing Education, 39th and Rainbow Blvd., Kansas City, KS 66103, (913) 588-4480. *April* 17–18

ELEVENTH ANNUAL TRENTON COMPUTER FESTIVAL, Trenton, NJ. TCF–86, Trenton State College, Department of Electronics Engineering Technology, Hillwood Lakes CN 550, Trenton, NJ 08625, (609) 771-2487. *April* 19–20

CONFERENCE ON EXPERT SYSTEMS AND ARTIFICIAL INTELLIGENCE IN PUBLIC POLICY, Syracuse, NY. Dr. Stuart Bretschneider, Technology and Information Management Program, The Maxwell School of Citizenship and Public Affairs, Syracuse University, Syracuse, NY 13210, (315) 423-1890. *April* 21–22

ROBOTS '86 CONFERENCE AND EXPOSITION: ROBOT APPLICATIONS FOR INTEGRATED MANUFACTURING, McCormick Place, Chicago, IL. Jeff Burnstein, Robotic Industries Association, POB 1366, Dearborn, MI 48121, (313) 271-7800. *April* 21–24

FOURTH ANNUAL CONFERENCE ON INTELLIGENT SYSTEMS AND MACHINES, Rochester, MI. Dr. Nan Loh, Center for Robotics and Advanced Automation, Oakland University, Rochester, MI 48063, (313) 370-2233. *April* 28–30

COMDEX/SPRING '86, Georgia World Congress Center, Atlanta, GA. The Interface Group Inc., 300 First Ave., Needham, MA 02194, (617) 449-6600. *April* 28–*May* 1

AI 1986: ARTIFICIAL INTELLIGENCE AND ADVANCED COMPUTER TECHNOLOGY CONFERENCE AND EXHIBITION, Long Beach Convention Center, Long Beach, CA. Tower Conference Management Co., 331 West Wesley St., Wheaton, IL 60187, (312) 668-8100. *April* 29–*May* 1 ■

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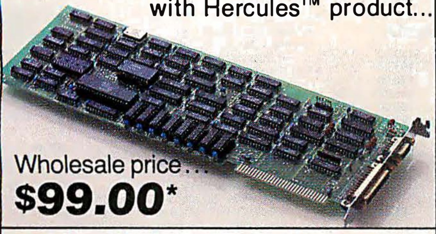
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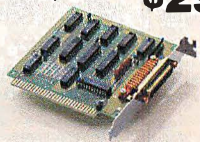


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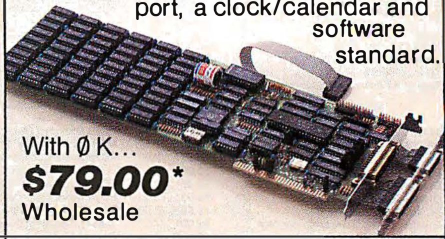
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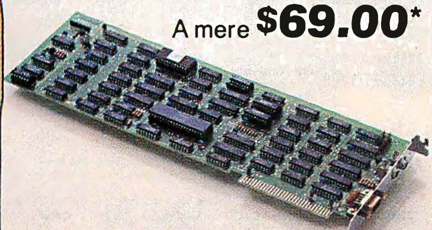


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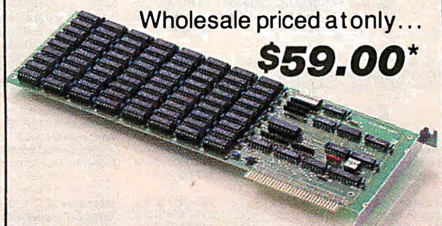


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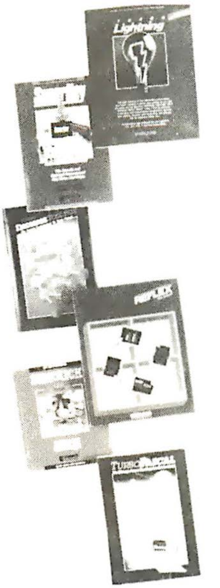
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Features

WITHOUT A SHADOW OF A DOUBT, this month's Circuit Cellar is a genuine departure for Steve. You won't learn how to build anything this time. Instead, Steve recounts an evening when things got very dicey for him . . . locked out of the Circuit Cellar, a monster security system facing him, the possibility of destruction descending on his neighborhood. Enlisting the aid of a doubting but helpful neighbor, Steve prepared to storm the Circuit Cellar. Did they succeed in preventing disaster? We're not about to tell you here.

This month's Programming Project is the final part of Bruce Webster's article on windows. He shows you how to close a window, describes pseudocode versions of the necessary routines, and gives code fragments from an implementation on an Apple II. Noting that many older microcomputers don't have windowing routines built in, Bruce hopes that his article will help you get started.

If you are tired of continually programming and erasing EPROMs as you develop software for your projects, you may be wise to construct the Emulo-8. Its creator, Stuart Ball, says that it's an ideal program-development tool on several counts and gives you all the details in "Build the Emulo-8."

Addressing themselves to system administrators, Alan Filipski and James Hanko examine some specific security-related features of the UNIX operating system, discuss methods of attack employed by crackers, and outline countermeasures that are effective against would-be invaders. The authors believe that administrators who are aware of potential problems can maintain their systems to provide sufficient privacy and protection for most applications.

Just as you should apply principles of structured programming to your programs, you should apply principles of data design to your database. In "Data Design" Leonard Shapiro offers valuable techniques for achieving this goal.

This month's Programming Insight, from Bruce Land, focuses on the recursive drawing of a dragon curve on the Macintosh. The Mac's high-resolution display and the rapid execution rate of MacFORTH produce the interesting image shown on page 137.



PHOTOGRAPHED BY PAUL AVIS

COMPUTER ON GUARD!

BY STEVE CIARCIA

A tale of overzealous computer security

Editor's note: Steve Ciarcia has been working with and writing about home-control systems for many years. This month's Circuit Cellar shows what could happen when a sophisticated system runs amok.

"Merrill, you gotta help me!"

The feeling of panic was coming over me as I beat on Merrill's back door. I needed help, and Merrill was the only person I could trust—the only person that would understand that I wasn't crazy. As I knocked on the door, I glanced over either side of my shoulders to make sure no one else was around.

"Merrill, you gotta help me!"

I stood next to the door in a shadow that the moonlight failed to illuminate. It was a cool spring evening. While the stars shown brilliantly in their quiet elegance, I couldn't help but fear that this would be the last quiet moment of the evening if I failed.

"Steve? What are you trying to do? Can't you just ring the bell and wait 30 seconds like everyone else?"

Merrill wasn't really mad, just startled at my wild-eyed look and disheveled appearance. I often visited him but usually announced myself by some means other than beating down his back door. He waited a few seconds. He realized that this wasn't a social call and changed his tone to one of concern.

"What's wrong? You look terrible."

"I locked myself out!"

For any other person in the world, that would not be a catastrophic occurrence. In fact, the words sounded a bit absurd as I said them. I only hoped that Merrill valued our friendship enough to listen to me.

"You locked yourself out? Didn't you once give me a key to hold just in case this ever happened?" Merrill was becoming increasingly curious as to why I should be so distraught. I should have known he had a key.

I nervously glanced at my watch and answered, "That was when one needed a key to get in my house." Such a statement obviously would lead to all kinds of conjecture, but I didn't have time to explain.

"What do you mean, no key? How do you get into your house? Whistle?" Merrill seemed a bit disturbed that I was playing guessing games.

"I don't use a key anymore. I use a digital code. I really don't have time to explain.

(continued)

Steve Ciarcia (pronounced "see-ARE-see-ah") is an electronics engineer and computer consultant with experience in process control, digital design, nuclear instrumentation, and product development. He is the author of several books about electronics. You can write to him at POB 582, *Glastonbury,* CT 06033.

Please, just put on some dark clothes and help me."

His help-thy-neighbor attitude took five giant steps back when I mentioned the necessity for dark clothes. Glancing at my watch once again to see how much time we had left, I determined that a portion of it had to be allocated for explanation. I stepped into the doorway and moved past Merrill.

"You see, Merrill, I've locked myself out of the house, and I have a soufflé in the oven."

Merrill looked at me like I was some kind of nut. He walked over to the kitchen sink and opened the cabinet doors beneath it, revealing a toolbox. "Look, we'll zip over and pull the hinges on one of the doors. It's a cinch."

Before he could pass me any tools, I interrupted him. "Merrill, it's not that easy. You don't understand. Let me explain."

The expression "Please do" was painted all over his face and needed no verbalization. As he sat down in the overstuffed chair, he extended and crossed his legs on the footstool and stroked his gray beard nervously. The little bit of fuzz on the top of his balding head seemed to bristle like a cat. To further the impression that he was ready for a real fish story, he took out a briar pipe and nonchalantly started to clean it. Between the sounds of tapping the pipe on the ashtray and blowing through the stem to clear it, he extended his hand toward me and said, "Do begin, please."

The delay was excruciating. It was critical to act soon. The soufflé was irrelevant. It was the chain of events that could be accidentally touched off that I was worried about. My only hope was to talk fast.

"Merrill, my house doesn't use a house key anymore because it has a computerized environmental and security control system!"

He puffed on the pipe and interjected, "Fair enough. But what's that got to do with the soufflé?"

"This isn't just any home-control and security system. I designed it! An advanced sensor system tied directly into my computer makes it about the most sophisticated home burglar alarm in the world. I got thinking one night that I needed a burglar alarm. Since practically all the lights and appliances were already connected to the control system, I just extended its capability a little. But I got a little carried away on the engineering, and I'm not sure I know how to get in without setting it off."



"Merrill, you gotta help me!"

Merrill was amused. Every time he and I had spoken lately, it had something to do with computers. He no longer thought I was completely crazy, just a little. There was still that one burning question, "What has that got to do with the soufflé?"

"There's a soufflé in the oven, and let's see . . . it should be done in 30 minutes. But the oven timer only buzzes. It doesn't shut the oven off. I know you're only an engineer and not Betty Crocker, but even you can guess that it wouldn't be more than another 20 to 30 minutes before it starts to burn."

I spoke rapidly. We were eating up precious seconds. "When the smoke from the burning soufflé hits the smoke detectors on my alarm system, all hell is going to break loose on this street."

"Wow! What does it do, call the police?"

Most people are familiar with the standard smoke and burglar alarms that automatically dial the fire department. While the end result was the same, my method was quite different. The sophistication of my home-control computer was unmatched by anything that commercial companies had to offer. That, in combination with the mind of your average, everyday mad scientist, can produce startling results.

"Well," I started rather sheepishly. It isn't often one has to explain the limits of his paranoia. "It isn't every day you have a fire in your house. When you do, you want action fast so you can reduce the damage and get people out in time. This system is predicated on everyone acting fast. When a fire or smoke is detected, it first sets off the alarm horns mounted outside next to the garage. I've never tried them, but they're war surplus air-raid sirens.

"Mathematically, the sound level coming out ought to be high enough to break about half the windows on the street. Mrs. Picker, who lives directly across from my house, will probably have her whole house moved back about two feet when they go off.

"Secondly, there are four xenon strobe aircraft-landing lights mounted on the corners of the house that will start flashing with about 2 million candlepower each. That was just in case the fire trucks had trouble finding the house.

"Then come the automatic telephone calls out on the three telephone lines. Remember, Merrill, my computer has a voice synthesizer, so I don't need a tape recorder. It definitely doesn't sound like a recording, so it should

ILLUSTRATED BY ELLIOTT BANFIELD

prompt immediate action. The first call is to the fire department. It also is simultaneously transmitted on CB channel 9. Then a whole bunch more. The end result is more cars and trucks than we can fit on this street."

The pipe in Merrill's mouth drooped lower and lower as I conveyed the consequences of my alarm going off. It was hanging down to his chin when he muttered, "Why don't you add me to the list of calls in case I miss the initial shock wave."

"Don't worry, Merrill! You're the ninth call!" Merrill definitely had a concerned expression. As I expanded upon the next step, it turned to terror.

"Merrill, you gotta help me break into my house and shut the alarm off before the soufflé burns."

The pipe fell out of his mouth, and the ashes formed a line down the front of his shirt. He barely noticed them as he exclaimed, "Are you crazy? Break into your own house?"

"Look, Merrill, I designed that system to prove I could do it. Now that I can count the seconds before I know it's going to go off, I recognize it as pure overkill. I'll replace it later with something more sane, like six Doberman pinschers and a minefield. But right now we have to stop it! Will you help me?"



"But what's that got to do with the soufflé?"

Merrill brushed the ashes off his lap and jumped up. "Do I need dark clothes?"

"Yes. I'll explain later. And wear a dark sweatshirt with a hood or something to cover your head."

The evening newspaper fell to the floor as it was sucked off the table by the vacuum created as Merrill ran to change. I could detect a cold sweat forming as I checked my watch repeatedly. It was only 10 minutes since we had first started talking, but now it was only 20 minutes before the soufflé would be done.

I could picture in my mind the progression of events that would follow. First, the soufflé would blacken and crack. Then, as it shriveled, some of the exterior sections would have dried enough to be combustible. The first whiffs of smoke would go unnoticed, but eventually a billowing cloud would spew forth from the oven. When it reached the smoke detectors, the computer would go into action. Our only hope was to get inside in time to stop the computer. If we failed, we had better make sure we were not standing next to one of those sirens when it blew. Further thoughts were interrupted as Merrill burst into the room fully dressed for action.

"I'm ready. Let's go."

Merrill looked like a cat burglar. The solid-black sweatshirt had a hood that completely covered his balding head, and, while his gray beard still showed, it aided the camouflage. His pants were equally dark and skintight. All reflective surfaces like belt buckles and key chains were carefully omitted. Black track shoes completed the outfit. I only hoped we didn't have to do too much running with all the rope, and as we jogged up the street toward my house, Merrill turned and asked, "You sure you know how to get in?"

The details of the computer alarm design flashed through my mind. I knew every wire, every sensor. Yes, I knew what the components of the system were. But the computer had far greater speed than I at analyzing the data received from them. A pressure switch activated in the wrong sequence, a heat sensor detecting human presence, any number of things could activate the alarm. I had let my inventive genius run "open loop." The tiny credit card that now lay on the coffee table in the living room had been my only control over the potential Frankenstein I had created. True, it would foil a burglar or call the fire department, but the ends to which I had gone in devising the system were aimed more at instant incineration of any perpetrator than protection of property.

To fully answer Merrill's question was impossible. I didn't know whether I could beat myself at my own game. "I don't know, Merrill. I hope so."

We stopped in front of my house. Almost magically a floodlight switched on to illuminate the area before us. Music could be heard from inside. A light in one room switched off, and another turned on. I didn't wait for Merrill to ask since I knew he was curious.

"Most of the AC outlets in the house are remote-controlled. The computer can control almost any light or appliance in the house, except the stove. The computer knows that something or someone is out here from microwave motion sensors planted in front of the house. No one is in the house, but it is simulating habitation by playing music and making it appear as though people are moving from room to room. Just for good measure, it turned the floodlight on to tell you that it knows you're here too."

(continued)

Merrill started toward the front walk. I grabbed his arm to stop him.

"Forget it. The only way into the house is through some window that doesn't have any sensors attached. They're in the back of the house. Possibly one of the bathroom windows would be the best to try."

"Hey, Steve, before I lay my life on the line to save your soufflé, do you mind telling what happens if we set off the burglar alarm while trying to break in. You already told me about the fire alarm."

My reputation had preceded me. The fire alarm was only part of the system. The burglar alarm was equally devastating.

"Well, there's a bunch of stuff I'll explain as we go along. It's too complicated to explain in detail. But the end result is that the computer determines the location of the perpetrator and then tries to lock him in the area where he has been detected and calls the police."

"If that's all, you can explain the accidental phone call to the police. They often get false alarms from automatic dialers."



"Mathematically . . ."

"Wait, you didn't let me finish. Then, it sets off all the sirens and lights, just for good measure. And, oh yeah, there's a very loud noise source inside the house that's triggered, which is supposed to temporarily disable the perpetrator. Then it does all the same telephone calls, explaining there is a break-in instead of a fire."

Merrill looked at me in amazement. The adventurer in him wanted to go full speed ahead and tackle the Mount Everest of electronic obstacle courses, while the quiet engineering instinct suggested that he go home and check his medical insurance first. He shook his head as he said facetiously, "Why didn't you just use tear gas?"

"Oh, I considered it. It's just too hard to get the smell out of the Oriental rugs."

This unexpected response was too much for Merrill. As we stood there in the moonlight, I could see the sweat forming above his brow.

To this point, he had been aiding an eccentric neighbor. Though it had taken a long time and not through any direct explanation, Merrill was ready to admit that this computer alarm had to be stopped. There was no animosity that I had created it, just a realization of the full consequences of its being.

He, too, looked at his watch and sensed the seconds ticking away. No longer was he along for the ride. Now he was a committed participant. "Let's go."

I knelt down next to a sandy area at the corner of the lot. Merrill looked over my shoulder. Grabbing a short stick to draw in the soft soil, I started to lay out the attack plan. "Here's the house, the property line, and key obstacles. There's only one way to approach the house from the rear and not be detected. We have to go over the side-yard fence, along through the brush to the pine trees behind the house, and then across the back lot. Have you done any pole-vaulting recently?"

"Pole-vaulting? Are you kidding? I just about have enough energy to go from the couch to the refrigerator for another beer. What are you talking about?"

His eyes opened wide and projected a common expletive. The general translation was, "Hey man, I agreed to break in a house with you, but I ain't pole-vaulting over no fence."

That was the easiest way, but I had to agree with Merrill. The years in the cellar being a mad inventor rather than a tennis pro had taken their toll. I wasn't about to pole-vault over any fence either.

"We've got to find a way over the fence without actually climbing on it. There are vibration sensors in the vertical supports that are meant to detect anyone climbing over it. Tripping it won't set the whole alarm off, but it will start a timer where the computer treats perimeter events more seriously. If during that period the computer senses too many motion and vibration inputs, it will treat it as a threat and react accordingly." I didn't elaborate on the latter.

We stood next to the fence. It was constructed of heavy wire mesh attached to metal supports. Trying to vault over such a fence and missing would be like putting your body into a cheese grater. It was only about 5 feet high though, so there had to be an easy way over it.

Merrill looked at the situation. I could see his engineering mind going to work. Pictures of levers, fulcrums, balances, and pulleys were flashing through his mind. Walking over to the tree adjacent to the fence, he started coiling a length of rope in one hand. With one mighty swing, he threw the coil of rope over a 20-foot-high tree limb hanging directly over and parallel to the fence. Now the rope hung down and touched the top of the fence.

"Come here, Steve," he said.

I was still a little puzzled, even as he looped the rope around under my arms and tied a knot at my chest. Only when he pulled on the other end and hoisted me off the ground did I realize how he intended to get us over the fence.

"Gee, Steve, why don't you lose a little weight for the next break-in?"

I felt like a side of beef hanging on a rope 6 feet off the ground. When he started swinging me from side to side, I thought I was going to get seasick. The amplitude of the swing got longer and longer until the arc carried me over the fence to the other side. The realization of what the next part of the sequence would be came a fraction too late for me to protest. As the arc carried me over the fence, Merrill let go of his end of the rope. Logically, I should have expected that this was the only way, but the experience of being swung on the end of that rope hadn't any semblance of logical reasoning on my part. My far-too-late protest started something like a "whoop" and concluded with the tonal equivalent of Tarzan merrily swinging through the jungle and suddenly missing the last vine.



"Gee, Steve, why don't you lose a little weight for the next break-in?"

The fall was only 6 feet, but it felt like a hundred stories. I thought that if that was a sample of things to come, maybe I should take my chances with the alarm. It didn't help matters when I landed sitting down. The ground was quite moist, and my clothing sucked up the water like a sponge. When I put my hand down to reorient my position, I felt the cold spring mud ooze between my fingers. The totality of my situation and the immediate sensations at hand were summed up with the single word, "Yech!"

As I turned to check on Merrill, I caught a glimpse of him sailing through the air. Rather than be hoisted, he had secured one end of the rope and tied large knots in the other to aid climbing. Once at the 6-foot level, he swung out over the fence as I had and let go. Even though he came down feet first, the momentum was too great for the terrain. It took only a fraction of a second for two skid marks to form behind his heels, and Merrill came crashing down in the same sitting position next to me. His first word was, "Yech!"

I glanced at my watch and realized there were only 10 minutes left on the oven timer. I said, "Come on, Merrill, we can't sit here like two idiots. There's not much time left. We have to head for the brush on the right and then crawl toward the pine trees."

"Crawl? Why do we have to crawl?"

"I'll explain when we get there. Right now, pull your hood up over your head like this. Whatever you do, don't look at the house as you run past the brush into the pines, or the computer will see you."

"What is this, a science-fiction movie or something? What do you mean see us?" Merrill's nervousness was evident by the shrillness of his voice. He should have believed me when I said it was the most sophisticated alarm installed in a home.

"Just that. See that small box on the corner of the porch roof?" I pointed to a small black rectangular enclosure suspended below the corner of the roof line. About every 10 seconds a small red light flashed, giving it the appearance of being activated.

"There's a digital television camera in that box that scans this section of the yard between a height of 3 and 7 feet. When that light flashes, it starts a scan and looks for changes in light patterns from one scan to the next. With our dark clothes, by running just ahead of the scan we should go unnoticed."

The 30 seconds it took while we watched the blinking light until we could anticipate the next scan seemed like an eternity. When the precise moment came, I yelled, "Head for the pines. Go!"

Running with both hands in our pockets to shield our skin from detection made trying to run at full speed rather awkward. It was more like a high-speed waddle than the statuesque gait of a long-distance runner. We had 5 seconds to make it to the pines before the camera would start to retrace its path and compare the new image to that of the preceding scan. It was barely 120 feet, but it took all our effort to achieve it in time.

As I was about to dive under the first pine for concealment, I remembered something vitally important. I crouched under instead. "Merrill, watch out where you walk. There is where my dogs . . . Oh, I see you just found out. Sorry about that, Merrill."

Merrill was apparently just mentally chalking it up on his list of reasons to strangle me when the escapade was over—which it wasn't. Standing out there in no-man's-land was not accomplishing the task. Pointing to his watch, he said, "We have 5 minutes. What's this about crawling?"

(continued)

"Don't worry about it, just crawl. Remember, we have to stay below 3 feet high. Don't stand up or we're dead. Ready? Go!"

Merrill still didn't understand why he was on all fours, crawling toward my house at ten o'clock at night. Life used to be so much simpler.

We were neck-and-neck about halfway across the yard when the computer spotted us. Two bright floodlights came on, illuminating the area where we lay. Merrill, exercising reflex actions learned from years in the Marines, instinctively dove into a prone position, as though he anticipated an imminent artillery barrage. At the same time the lights came on, the tumultuous roar of many vicious, snarling dogs filled the yard.

Frozen in his position, Merrill yelled, "What have you got, a pack of hungry timber wolves in the basement? What do you need an alarm for?"

"Don't talk. Just bark!"

"Bark?" Merrill looked at me and shook his head.

"Bark," I said. "Like this. Arf! Arf! Arf!"



"Bark," I said. "Like this. Arf! Arf! Arf!"

Soon we were both barking and woofing up a storm. My two Scotties would be proud of us. We kept it up for about 25 seconds, until the lights and the ferocious dogs stopped as miraculously as they had started.

Speaking very softly and not waiting for questions, I said, "Hey, you can stop barking. There's a laser perimeter intrusion detector in this corner of the yard. It sensed our presence below the 3-foot level. It turned on the floodlights and the recorded sounds of barking dogs to see what it was or try to scare it off.

"Now, here's what the computer is great for. After all that was triggered, the computer turned on a microphone to listen out here at the same time. When it heard us barking the same as any real dog would do upon hearing the recording, it shut off the alarm sequence. You see, Merrill, the computer thinks we are just a dog that wandered through the yard and not an intruder. A real burglar, smart enough to see the different sensors and trying to crawl as we have been doing, wouldn't know enough to bark back at the computer. Neat, huh? Now we can finish crawling to the house. It won't bother us again."

Merrill rolled his eyes and put his muddy palm to his sweat-laden forehead. As straight-faced as one could be, all things considered, he said, "Steve, you're crazy."

Not wishing to argue, since time was running out, I merely responded, "Genius is never appreciated until it's too late."

"Steve, tell me why I'm going through all this. What do you have in your house that is so valuable that you installed a system designed to counter an invasion?"

"Well, if I really think about it, I guess the computer control system and all the alarm sensors are probably worth the most."

Merrill didn't know how to respond to that information. We computer hackers design things sometimes just for the challenge. Unfortunately, this particular challenge was getting out of hand, and time was very short.

The remaining distance across the lawn was far less wasteful than the first. We encountered no land mines, bear traps, or quicksand. We finally found ourselves resting against the house just below the bathroom window. Reaching the next objective was not as bad as the preceding events. The window lock was easily pried open with a pinch bar. I warned Merrill not to make any noise once he was inside the house. Then I hoisted him up to the window. Grabbing the top of the window frame for support, he lifted himself off my shoulders and knelt on the window ledge. Next, trying to be as graceful as he could in such an awkward position, Merrill swung his body around so that he now sat on the sill, with the trunk of his body hanging outside the window and his legs projecting inside. Once in that position, it was easy to swing into the bathroom and land squarely on the floor.

In a gymnasium, Merrill would have executed it perfectly. A small bathroom was quite another story. One foot came down squarely on the carpeted floor, as it should have. The other foot came down squarely into the open toilet, as it shouldn't have. Remembering that I had warned of excessive noise, he cussed very quietly as he extracted his foot from the toilet.

As he leaned out the window to help pull me up, he said, "Hey, Steve, I hear some kind of buzzer in the house."

I quickly glanced at my watch and responded, "That's the oven timer. It's running a little faster than I thought. Now the soufflé is overcooking. Help me up. We haven't got much time."

Merrill leaned out the window and grabbed the shoulders of my sweatshirt as I jumped up to the window

ledge. My entrance was far less graceful than his. I had no alternative but to go through the window head first. I'd swear that Merrill directed my flight toward the toilet on purpose, but I have no proof. At the last instant, I was able to extend an arm and apply a force opposite to that of my trajectory. The result was a dull, rolling thud on the bathroom floor.

Our totally disheveled appearances lent no levity to the situation. But we were inside the house, and the stove was just 20 feet away. If we could get to the soufflé in time to stop it from burning, we would have all the time in the world to shut off the rest of the alarm. "Merrill, don't say anything louder than a whisper. There are mikes planted around the house, and the computer is listening for loud noises." I extended a forefinger against my lips to dramatize what I had said.



I'd swear that Merrill directed my flight toward the toilet on purpose, but I have no proof.

"Steve, I just saw something outside. Outside near the fence in the backyard!" Merrill was looking out the window, and after a few moments he excitedly pointed over my shoulder toward a dining room window, visible from the bathroom even though it was on the other side of the house. "There it is again!"

I jerked around in time to detect motion from an unknown object. "What do you think it is, Merrill?"

Before he had time to answer, a human form stood for a second in front of the window. Extending from an arm was a long, slender object. For a moment, Merrill and I just stood with our mouths open watching the proceedings. The figure turned suddenly. The slender object exhibited a metallic gleam in the moonlight. Then the figure was gone, as quickly as it had appeared.

We looked at each other. Our eyes were wide open as we whispered in unison, "I think that was a gun!"

"I think we have a real prowler, Steve. What are we going to do? He has a gun, too!"

"Don't ask me! Remember, I'm stuck here, too."

"Suppose. Now just suppose he was able to get by all the alarms and got into the house. And just further suppose he fills his pillowcase and is about to leave when he decides to go to the bathroom. Voilà, us two looking down the barrel of that gun!"

"Shhh, Merrill. Don't be an alarmist. Nobody can get through my alarm system."

Simultaneously, as Merrill spoke them, I thought of the exact same words, "But we did!"

The situation presented a problem. Should I leave the oven on and purposely trigger the alarm to bring help and catch the prowler? Or should we still try to finish what we had started and then hope the perpetrator wasn't smart enough to make it through my alarm?

I looked at my watch. The soufflé had to have been over-cooking about 10 minutes. The stove timer was buzzing relentlessly in the background. I sniffed the air. What had previously smelled freshly baked now had the scent of being overdone. It would still take a few minutes before smoke would be produced that the computer could smell. We were in a real dilemma. We were caught between our protector and the prowler.

"Steve, look again!" Merrill pointed toward the dining room window. "It's a woman!"

The figure was in full moonlight in front of the window. The features were easily discernible, and I recognized the person immediately. The metallic glint previously thought to be a gun was the stainless-steel tip of a walking cane. I grabbed Merrill's arm tightly and said, "That's no woman. That's Mrs. Picker from across the street."

"Is that bad?" Merrill had little experience with Mrs. Picker. He could not fully comprehend the grave position we were now in.

"That's worse than any prowler with 10 guns. She probably saw us and thinks we are the prowlers."

"Boy, that must really take guts to confront two prowlers single-handedly." Merrill still didn't understand what I was trying to tell him.

"That feisty old lady might be 80, but I wouldn't put it past her to climb over the fence after us if she discovered the rope. What I'm really worried about is that while she's looking for us, she'll probably set the alarm off. When the law arrives, guess who is wearing the cat-burglar costumes and covered with mud?"

Merrill looked down at his clothes and back up at me. His eyes pleaded with me to act fast. We were in the worst possible combination of circumstances to be caught in. The only solution was to try to turn off the system before Mrs. Picker triggered it.

"Let's go," I said. "We still have to turn the oven off."

Merrill agreed. We had no other choice. Extra time to shut off the system was gone. First, we had to get to the

(continued)

stove. Motioning to Merrill that he should follow in my exact footsteps and mimic my every motion, like a childhood game, we started the ordeal.

"Merrill, see those two holes on either side of the door molding? Those are photosensors. The computer can tell if we pass through the door and in what direction we are going. Fortunately, they are only 18 inches off the floor."

At the doorway of the bathroom, I lifted my right leg very high and extended it out over the other side. Shifting my weight to the now firmly planted foot outside the bathroom, I retracted the other leg by reversing the process. Merrill followed suit. We stood in the back hallway outside the bathroom.

"Every doorway we go through, we will have to follow the same procedure. Got it?" Merrill nodded affirmatively as I continued to whisper. "Now step over this area and these other two. There are pressure switches under the rug that will go off if you step on them. Try not to make too much noise jumping. Remember the mikes!"



Mrs. Picker

Ordinarily, all these sensors and switches caused the computer to turn on lights and direct the stereo system to the appropriate rooms as I walked through the house, all in the name of convenience. Now, however, the feeling we had was like being in combat. We were in the middle of a minefield directing those behind to follow in our footprints. While the sensation of stepping on a mine could not be exactly equaled by my computer, the heart attack following the first sound of that air-raid siren could be just as lethal. We silently high-stepped and hopscotched our way through the house until we reached the stove.

As I extended an arm to turn the oven off, I could see the blackened soufflé through the oven door's window. It was very disconcerting to see a creation of one's hand and mind shriveled and destroyed. But the realization that we were still at the mercy of another such creation prompted a fast exit. We had not gotten to the stove too soon. Inside it was filled with smoke. While not so dense as to obscure total view, I dared not open the oven door. The smell was of burned baked goods, but it was not dense enough for the computer to get excited about—yet.

Our final objective was the cellar, where the computer was headquartered. It was quicker to go there than try to find and insert the digital card in the reset mechanism in the front hallway. The motion sensors in that area of the house were not as easily overcome as the simpler variety that we had thus far defeated. The cellar door was but 5 feet and one pressure switch from the stove. We made it to this objective as easily as we had the others. There was no sensor on the door. I opened it slowly so that the squeaking of hinges would not reach an appreciable volume level.

When we opened the door, my two Scotties looked up at us. "No time to play now, guys," I said.

I went bounding down the stairs with Merrill in close pursuit. "When the alarm is activated, the dogs are kept in the cellar. So there are just a few sensors down here. We're home free now!"

Merrill and I stood in front of the computer control system. This computer did not have the usual panel full of flashing lights. That was old hat. The new stuff all had cathode-ray-tube displays. The monitor attached to the control system displayed a matrix of control parameters and on/off state. Peripheral sensors, not directly used to determine specific alarm conditions and still experimental, scanned the grounds like radar and displayed their activity around an outline of the house on another monitor. A dot flashed on the screen next to the outline. It slowly moved around the periphery of the house.

"That's Mrs. Picker." I pointed out to Merrill. "The computer knows she's out there. It has turned on the lights, but it will ignore her unless she goes over the fence into the backyard. See, she's moving in that direction now. I'll need about 3 minutes to enter the disarm commands."

Merrill looked around the cellar at all the equipment. Spying a refrigerator, he started to walk toward it. "Hey, Steve, why can't you just pull the plug on the computer?"

"That wouldn't do anything. In case of a power failure, the computer has battery backup and all kinds of redundancy."

I started to type in the first abort code. Merrill, who finally felt relaxed again, stood at the refrigerator and said, "Boy, all this work has really made me thirsty. Do you have any beer in here?"

He opened the refrigerator door. The fact that the refrigerator contained refreshment became immediately irrelevant. Suddenly a small speaker next to the computer started to emit a loud, repetitive sound: beep . . . beep . . . beep . . . beep.

"Merrill! You triggered the alarm! It's going to go off in 10 seconds!"

My mind raced with the thoughts of things that were about to happen. Everyone but the National Guard would be here in 10 minutes. Large jetliners approaching the nearby airport would be distracted by the brilliant flashing lights and start to circle the house instead. They would find Merrill and me in a state of partial rigor mortis from the loud horns that would now go off inside the house. The computer had sensed an intruder. Finally, and most important, there was Mrs. Picker. If she was standing next to one of those sirens when it started, it would be curtains!

Merrill's eyes bulged with terror. Internally, he screamed, how could this be happening? Vocally, he yelled, "I thought you said that there were very few sensors down here because of the dogs! Why did it go off?"

Simple, yet true. We were done for, but he still had to know. "Dogs don't open refrigerator doors. That's why."



"Give me a minute or two to fix it, and I'll show you that the sirens really do go off."

The 10 seconds had almost elapsed. My final words were, "Hit the deck! Cover your ears!" That was exactly what we did. It was a hard-tiled cement floor, but we dove under one of my workbenches and covered our heads with our arms. Almost immediately the beeping stopped. Then, silence. . .and more silence. . .and more silence. After about 15 seconds I peeked out. At 30 seconds we got up and walked over to the computer.

"I don't understand," I said. "It should have gone off. At the end of the beeping, it should have started the sirens and lights and everything. I don't understand."

I walked over to the console and started to list the program on the display. "There must be a program bug or a loose wire in the back here someplace. Otherwise, it would have gone off." I busily typed on the keyboard as I spoke. "Gee, Merrill, that's a lousy demonstration of my talents. I'm a better programmer than that.

"Merrill, wait a few minutes, and let me see if I can fix it. Don't think this was all a waste of your time. I want you to know that this thing really works. Give me a minute or two to fix it, and I'll show you that the sirens really do go off."

Merrill didn't wait. He gave me a fierce glance and took off up the staircase. I yelled, "Where are you going? Don't you believe this will work?"

Merrill yelled down the stairs. "I'll be right back. I'm just going to borrow Mrs. Picker's cane!"

CIRCUIT CELLAR FEEDBACK

This month's feedback is on page 336.

NEXT MONTH

Adding SCSI expansion to the SB180. ■

This story was adapted from the chapter called "Computer ON Guard" in "*Take My Computer. . . Please!*" by Steve Ciarcia and is reprinted by permission of Scelbi Publishing.

Autographed copies of my hardbound book "*Take My Computer. . . Please!*" can be obtained for $10 including shipping (add $6 outside continental U.S., $4 for Canada). Send check or money order directly to me at POB 582, Glastonbury, CT 06033.

There is an on-line Circuit Cellar bulletin-board system that supports past and present projects. You are invited to call and exchange ideas and comments with other Circuit Cellar supporters. The 300/1200-bps BBS is on line 24 hours a day at (203) 871-1988.

Due to an overwhelming response and increased production rate for the SB180, as described in the September and October 1985 Circuit Cellars, the assembled and tested SB180-1-20 "BYTE Readers' Special" price of $499 has been extended indefinitely by Micromint.

To be included on the Circuit Cellar mailing list and receive periodic project updates and support materials, please circle 100 on the reader-service inquiry card at the back of the magazine.

Editor's Note: Steve often refers to previous Circuit Cellar articles. Most of these past articles are available in book form from BYTE Books, McGraw-Hill Book Company, POB 400, Hightstown, NJ 08250.

Ciarcia's Circuit Cellar, Volume I covers articles in BYTE from September 1977 through November 1978. *Volume* II covers December 1978 through June 1980. *Volume* III covers July 1980 through December 1981. *Volume* IV covers January 1982 through June 1983. *Volume* V covers July 1983 through December 1984.

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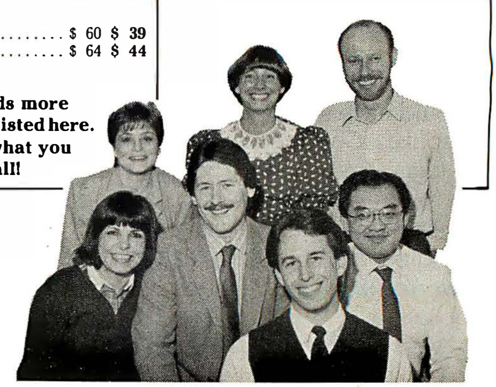
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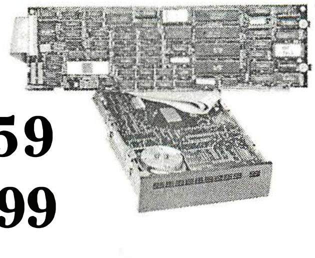
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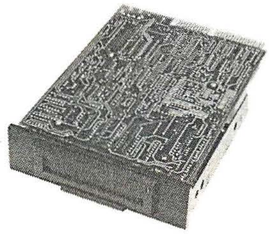
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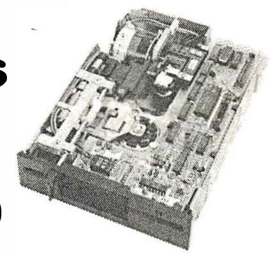
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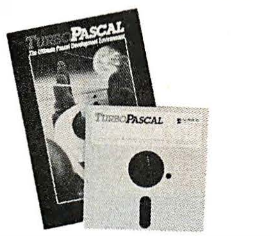
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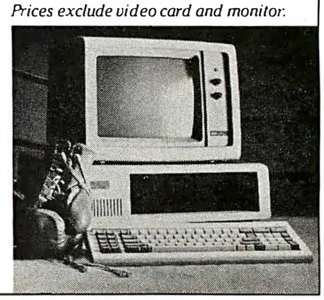
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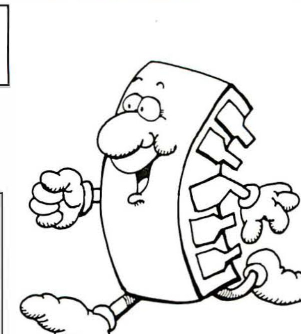
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A SIMPLE WINDOWING SYSTEM

PART 2: IMPLEMENTATION

BY BRUCE WEBSTER

This final part includes code fragments from an actual implementation

Last month, I talked about the basic ideas underlying windows and outlined a simple windowing system based on the following assumptions: (1) a bit-mapped graphics or byte-mapped text display; (2) an existing library of graphics or screen routines providing a few specific capabilities; (3) byte-aligned windows; (4) only one active (last-opened) window at a time; and (5) automatic restoration of background on window closing.

I also discussed the issues and problems behind opening a window and made additional decisions about how this system would work, most of which aimed toward keeping the system as simple as possible.

This month, I'll show you how to close a window. You'll then see a pseudocode implementation of the OpenWindow and CloseWindow routines. Following that, you'll be able to look at code fragments from an actual implementation on the Apple II.

CLOSING A WINDOW

Closing a window is, for the most part, simpler than opening it. The first step is to retrieve the window information: location, size, and screen data. By screen data I mean the screen information that was covered when the window was open. I've been using a last-opened/first-closed approach; the most recently opened window is the one you close first. The information for that window is still sitting in the window buffer in RAM, so that's where you look.

Using the window information, copy the screen data back over where the window is, making the window disappear. This is a simple reversal of the routine that copied the screen data into the window buffer in the first place. If no more windows are open, set the viewport to encompass the entire screen. The window is now closed.

If other windows are still open, the next most recent one must have its information copied to the RAM buffer. This information may be stored out on disk, or (given sufficient RAM) it may be sitting in memory. In either case, you must move it to the window buffer and note the change in mass storage. Finally, retrieve the values for location and size to set the viewport (or clipping region) for the newly restored window.

PSEUDOCODE VERSION

Having made the various design decisions concerning your windows, you can now develop pseudocode versions of the nec-

(continued)

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By writing your routines in pseudocode, you can then convert them to the language you are working in.

essary routines. Pseudocode is just an English-like programming "language" that has two goals: readability and ease of translation into actual programming languages. By writing your routines in pseudocode, you can then convert them to whatever language you happen to be working in. You also avoid the problem of remembering the syntax and peculiarities of a particular language.

Listing 1 shows the global declarations needed for the routines. The constants are all system-specific values; PPB, the pixels per byte value, is needed only if a graphics display is involved. You could declare two of the three variables—BufAddr and BufSize—as constants if the window buffer's address and size are known at compilation time and never change. BufUsed is a flag signaling whether anything is currently stored in the buffer; it should be set to False at the start of the program.

StoreBuf and FetchBuf are user-written routines that allow multiple windows to be opened. StoreBuf copies the current buffer contents to some other location—typically a disk—while FetchBuf copies the most recently saved buffer back to the buffer area. (If you have lots of memory, you'll probably want to take a different approach and dynamically create a new buffer of the appropriate size for each window you open.) ScrAddr is a function that returns the memory address of the location (*x,y*) on the screen. Viewport, ClearScreen, and DrawBox should all exist in your graphics/screen library in some form. If they don't, you can easily write them from routines that do exist.

Listing 2 shows a pseudocode version of the OpenWindow procedure. The parameters passed to OpenWindow are those chosen last month: the coordinates of the upper left corner and the width and height of the window. OpenWindow returns an error code indicating whether or not the window was successfully opened and, if not, why not. The X1 and Width parameters are in bytes, not pixels. This is to simplify placing the window and saving its contents to a buffer.

The first step in OpenWindow is to initialize some variables, then detect any error conditions. Four possible errors are checked for: the window is too big for the buffer; the upper left coordinates are off the screen; the window is too wide or tall to fit on the screen; or there is no room to store the data already in the buffer. If any of these situations occur, the parameter Error gets the appropriate value, and OpenWindow ends.

The next major step is to save in the buffer that portion of the screen that the window will cover. First, though, you need to save the information needed to restore the buffer later: the coordinates of the corner and the width and height of the area saved. This code assumes that each of those values are 2 bytes long and thus take up the first 8 bytes of the buffer area. (The notation BufAddr[i..j] indicates the range of bytes from BufAddr + i to BufAddr + j, inclusive.)

The following loop then calculates the starting address of each line in the window's area and copies that line into the buffer. This code assumes that each line consists of contiguous bytes and that the Width parameter represents the true width in bytes. These assumptions are not universal. For example, the Amiga uses a multiple-plane bit-map approach, which spreads the bits for each pixel throughout memory, while the IBM PC uses 2 bytes per character on its text display, requiring adjustments for either Width or X2. You'll need to make the appropriate changes for your environment. Also note that the flag BufUsed is set to True, indicating that the buffer now contains screen data.

Having saved that portion of the screen out to the buffer, you can now draw the window. A simple (and sys-

(continued)

Listing 1: *Global declarations used in* OpenWindow *and* CloseWindow.

```
global constants
  XMin     = lowest allowed X value (bytes)
  YMin     = lowest allowed Y value (lines)
  XMax     = highest allowed X value (bytes)
  YMax     = highest allowed Y value (lines)
  PPB      = pixels per byte;
             used to convert coordinates for window

global variables
  BufAddr = address of window buffer
  BufSize = size (in bytes) of window buffer
  BufUsed = flag indicating that buffer has window in it

global procedures
  StoreBuf      = routine to copy buffer to backup area
                  (other buffer, disk, etc.)
  FetchBuf      = routine to read buffer from backup area
  ScrAddr       = function that returns memory
                  address of location (X,Y)
  Viewport      = routine to set up viewport
  ClearScreen   = clears current viewport
  DrawBox       = draws box using upper left,
                  lower right corners
```

Listing 2: *Pseudocode version of* OpenWindow.

```
procedure OpenWindow(X1,Y1,Width,Height,Error);
parameters
  X1      = coordinate (byte) of upper left corner
  Y1      = coordinate (line) of upper left corner
  Width   = width (in bytes) of window
  Height  = height (in lines) of window
  Error   = returns error code, if any

local variables
  Size    = size (in bytes) of window to be opened
  X2      = coordinate (byte) of lower right corner
  Y2      = coordinate (line) of lower right corner
  Line    = current line being copied to buffer
  Addr    = starting address of that line
  BStart  = starting address in buffer for that line

start code for OpenWindow
// initialize variables
-- set Error = 'no error'
-- set Size = 8 + Width*Height
-- set X2 = X1 + Width - 1
-- set Y2 = Y1 + Height - 1

// do error checking
-- if Size > BufferSize then
     Error = 'Too big'
     exit OpenWindow
-- if X1 not in XMin..XMax or Y1 not in YMin..YMax then
     Error = 'Bad coordinates'
     exit OpenWindow
-- if X2 not in XMin..XMax or Y2 not in YMin..YMax then
     Error = 'Window too large'
     exit OpenWindow
-- if BufUsed = True then
     call StoreBuf(Error)  // save buffer out to disk //
     if Error <> 'no error' then
       exit OpenWindow

// copy underlying screen area out to buffer
-- store X1 at BufAddr[0..1]
-- store Y1 at BufAddr[2..3]
-- store Width at BufAddr[4..5]
-- store Height at BufAddr[6..7]
-- set BStart = 8
-- for Line = Y1 to Y2 by 1 do
     set Addr = ScrAddr(X1,Line)
     copy Addr[0..Width-1] to
          BufAddr[BStart..BStart+Width-1]
     set BStart = BStart + Width
-- set BufUsed = True

// set up window on screen
-- if graphics display then
     set X1 = X1 * PPB
     set X2 = X2 * PPB
-- call Viewport(X1,Y1,X2,Y2)
-- call ClearScreen
-- call DrawBox(X1,Y1,X2,Y2)
-- call Viewport(X1+1,Y1+1,X2-1,Y2-1)
end code for OpenWindow
```

tem-dependent) calculation is made to convert byte values to pixel values, if you are using a graphics display. You then set up a viewport for the entire area, clear it, draw the border, then reset the viewport to just within the border. OpenWindow is now done.

Listing 3 shows the pseudocode version of CloseWindow. CloseWindow first makes sure there is a window to be closed; that is, the buffer contains screen data. If not, it exits with an error; otherwise, it continues by retrieving the location and size values from the buffer. Having done that, it can then copy the screen data to the screen itself, erasing the window by restoring what was underneath. CloseWindow must now see if other windows are open. It does this by calling FetchBuf, which copies (from disk, presumably) the data for the next most recently opened window. If successful, FetchBuf sets BufUsed to True; otherwise, it sets BufUsed to False. CloseWindow checks BufUsed and, if it is True, extracts from the buffer the information needed to set up the viewport for the now-active window. If BufUsed is False, the viewport is set up to cover the entire screen. CloseWindow is now done.

Listing 3: *Pseudocode version of* CloseWindow.

```
procedure CloseWindow(Error)
parameters
  Error   = returns error code, if any
local variables
  X1      = coordinate (byte) of upper left corner
  Y1      = coordinate (line) of upper left corner
  Width   = width (in bytes) of window
  Height  = height (in lines) of window
  X2      = coordinate (byte) of lower right corner
  Y2      = coordinate (byte) of lower right corner
  Line    = current line being copied to buffer
  Addr    = starting address of that line
  BStart  = starting address in buffer for that line

start code for CloseWindow
// check for window to close
-- set Error = 'no error'
-- if BufUsed = False then
     set Error = 'no window to close'
     exit CloseWindow

// get X1,Y1,Height,Width
-- get X1 from BufAddr[0..1]
-- get Y1 from BufAddr[2..3]
-- get Width from BufAddr[4..5]
-- get Height from BufAddr[6..7]

// copy buffer back to screen
-- set BStart = 8
-- set Y2 = Y1 + Height - 1
-- for Line = Y1 to Y2 by 1 do
     set Addr = ScrAddr(X1,Line)
     copy BufAddr[BStart..BStart+Width-1] to
              Addr[0..Width-1]
     set BStart = BStart + Width

// set up underlying window, if any
-- call FetchBuf
-- if BufUsed = True then
     get X1 from BufAddr[0..1]
     get Y1 from BufAddr[2..3]
     get Width from BufAddr[4..5]
     get Height from BufAddr[6..7]
     set X2 = X1 + Width - 1
     set Y2 = Y1 + Height - 1
     if graphics display then
       set X1 = X1 * PPB
       set X2 = X2 * PPB
     Viewport(X1+1,Y1+1,X2-1,Y2-1)
   else
     Viewport(XMin,YMin,XMax,YMax)

end code for CloseWindow
```

A SPECIFIC IMPLEMENTATION

I've implemented a few windowing systems on different microcomputers. For example, I wrote a graphics-based Pascal version on the Apple II. The version made no disk access at all. Instead, it used RAM to hold all window buffers; you can continue to open windows as long as you have enough memory left. Listing 4 shows some excerpts from that program. You should notice a few things. First, the variant record type, BufRec, is designed to let you create an array anywhere in memory, so you can copy data from the screen to the buffer and back without much trouble. Second, the function ScrAddr returns the starting memory address of each line on the screen, according to the rather bizarre memory-mapping scheme on the Apple II. Third, the procedure DoXfer handles the grunt work of the actual copying of what lies behind a win-

Listing 4: *Excerpts from the Apple II Pascal version.*

```
const
  XMin    =     0;
  XMax    =    39;
  YMin    =     0;
  YMax    =   191;
  PPB     =     7;
  BufAddr = 16384;
  BufSize = 16383;

type
  Byte          = 0..255;
  Direction     = (Save,Restore);
  ByteBuffer    = packed array[0..BufSize] of Byte;
  BufRec        =
    record
      case Boolean of
        False  : (Addr    : Integer);
        True   : (BBuf    : ^ByteBuffer)
    end;

var
  BufUsed       : Boolean;
  Buffer        : BufRec;
  Offset,OldOff: Integer;

function ScrAddr(Line : Integer) : Integer;
var
  Addr,Temp          : Integer;
begin
  Line := 191 - Line;
  Addr := 8192 + 1024 * (Line mod 8);
  Temp := (Line div 8) mod 8;
  Line := Line div 64;
  ScrAddr := Addr + 128 * Temp + 40 * Line
end; { of func ScrAddr }

function DoXfer(Dir : Direction; var Buffer : BufRec);
var
  X1,Y1,Y2,Width,Height,BStart,Line : Integer;
  TBuf                 : BufRec;
begin
  with Buffer do begin
    X1     := BBuf^[Offset];
    Y1     := BBuf^[Offset+1];
    Width  := BBuf^[Offset+2];
    Height := BBuf^[Offset+3];
    BStart := Offset + 4;
    Y2     := Y1 + Height - 1;
    for Line := Y1 to Y2 do begin
      TBuf.Addr := ScrAddr(Line);
      if Dir = Save
        then MoveLeft(TBuf.BBuf^[X1],BBuf^[BStart],Width)
        else MoveLeft(BBuf^[BStart],TBuf.BBuf^[X1],Width);
      BStart := BStart + Width
    end
  end
end; { of proc DoXfer }

procedure OpenWindow(X1,Y1,Width,Height : Integer;
                     var Error : Integer);
var
  Size,X2,Y2         : Integer;
```

(continued)

dow either to or from the buffer. Fourth, since the values X1, Y1, Width, and Height are all limited to 8-bit values (0..255), they use up only a single byte each in the window buffer, rather than two (as indicated in the pseudocode).

Be warned that this version is not very fast. The turtle-graphics unit used for the graphics sets no speed records, and, as you can see, all the windowing code is done in Pascal. Speed will improve significantly if you turn DoXfer into an assembly-language routine, especially if you use lookup tables to compute each line's address. You can improve things even more by throwing out turtle graphics and writing your own graphics library, which I've already done. . . but that's a topic for another article.

POSSIBLE EXTENSIONS

As I said from the outset, this is a simple windowing system. Many things it doesn't do could be added with varying amounts of effort. For example, you might want to let windows exist on pixel boundaries, instead of just byte boundaries. It isn't too difficult to do, really. You still save out entire bytes, but you must now create and save in the buffer a mask for each edge of the window. When you restore the underlying data to the screen, you then use the mask at the beginning and end of each line to preserve those leftmost and rightmost pixels that should not be overwritten.

If you have enough RAM, you can keep all window buffers in memory and dynamically allocate new buffers as needed. This has many advantages. First, you can open and close windows faster since there is no disk access. Second, you don't have to worry about window size versus buffer size unless you are running out of memory completely. Third, there is little (if any) wasted space since each buffer is exactly the size needed. Again, the changes necessary are minor.

Another possible extension would let you move a window around. This isn't too difficult, assuming that you're moving the topmost (active) window.

(continued)

```
begin
  Size := 6 + Width*Height;
  X2   := X1 + Width - 1;
  Y2   := Y1 + Height - 1;
  (* error checking goes here -- removed for space *)
  with Buffer do begin
    BBuf^[Offset  ] := X1;
    BBuf^[Offset+1] := Y1;
    BBuf^[Offset+2] := Width;
    BBuf^[Offset+3] := Height;
    DoXfer(Save,Buffer);
    OldOff := Offset;
    Offset := Offset + Size;
    BBuf^[Offset-1] := OldOff div 256;
    BBuf^[Offset-2] := OldOff mod 256;
    BufUsed := True
  end;
  X1 := X1 * PPB;  X2 := X2 * PPB;
  Viewport(X1,X2,Y1,Y2);
  FillScreen(White);
  ViewPort(X1+2,X2-2,Y1+1,Y2-1);
  FillScreen(Black)
end; { of proc OpenWindow }

procedure CloseWindow(var Error : Integer);
var
  X1,X2,Y1,Y2,Width,Height    : Integer;
begin
  (* error checking again omitted for space *)
  Offset := OldOff;
  DoXfer(Restore,Buffer);
  If Offset = 0
    then BufUsed := False
  else with Buffer do
    OldOff := 256*BBuf^[Offset-1] + BBuf^[Offset-2];
  if BufUsed then with Buffer do begin
    X1     := BBuf^[OldOff] * PPB;
    Y1     := BBuf^[OldOff+1];
    Width  := BBuf^[OldOff+2];
    Height:= BBuf^[OldOff+3];
    X2     := X1 + PPB*Width - 1;
    Y2     := Y1 + Height - 1;
    ViewPort(X1+2,X2-2,Y1+1,Y2-1)
  end
  else ViewPort(0,279,0,191)
end; { of proc CloseWindow }

procedure Initialize;
begin
  InitTurtle;
  Offset := 0; OldOff := 0;
  BufUsed := False
end; { of proc Initialize }
```

My first windowing system, which was for an Apple II, was easy to write and worked well.

Once you've determined the new location for the window, you do the following:

1. Copy the window's contents out to a special buffer.
2. Copy the contents of the regular buffer out to the current location on the screen.
3. Copy the screen data at the new location to the regular buffer.
4. Copy the contents of the special buffer to the new location on the screen.

Two popular window functions are resizing (changing the size of the window) and reordering (bringing hidden windows up to the top). You can handle these functions easily if you are willing to force the programmer to redraw the contents of the window. If you want to maintain the current approach, though, these functions are difficult to implement. Resizing is probably the easier of the two, requiring you to modify just the data in the current window buffer. Reordering, though, can force you to make changes throughout all the buffers, changes that are tedious to calculate and implement. This is another of those exercises left to the reader.

CONCLUSION

I wrote my first windowing system for a 48K-byte Apple II some years back. I was surprised how easy it was to write and pleased with how well it worked. While the newer breed of microcomputers (Macintosh, Atari 520ST, Amiga) have windowing routines built in, there are still several million older micros out there for you to play with. I hope this article helps you get started. ■

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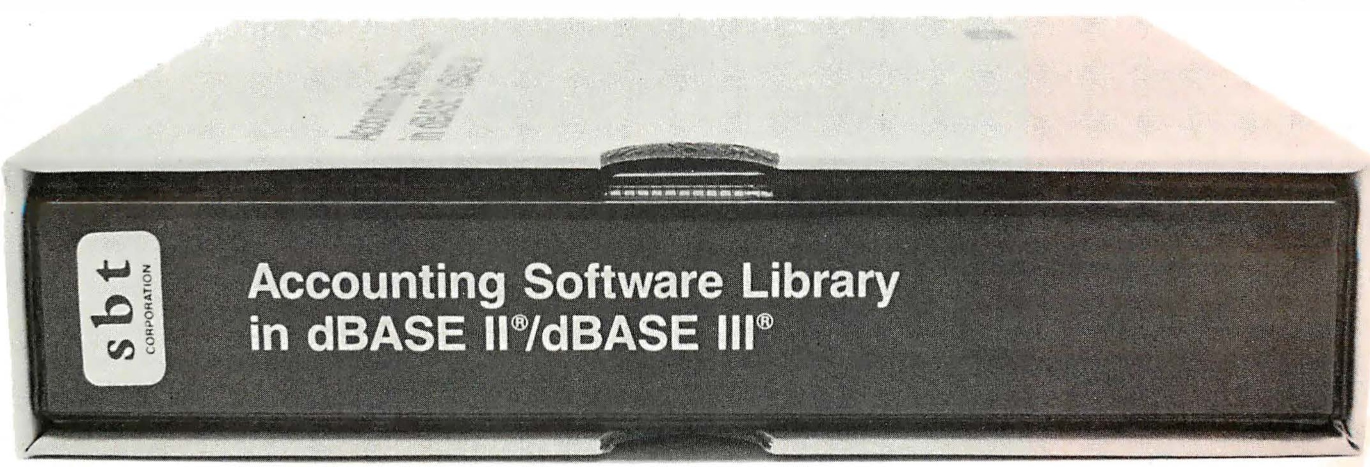
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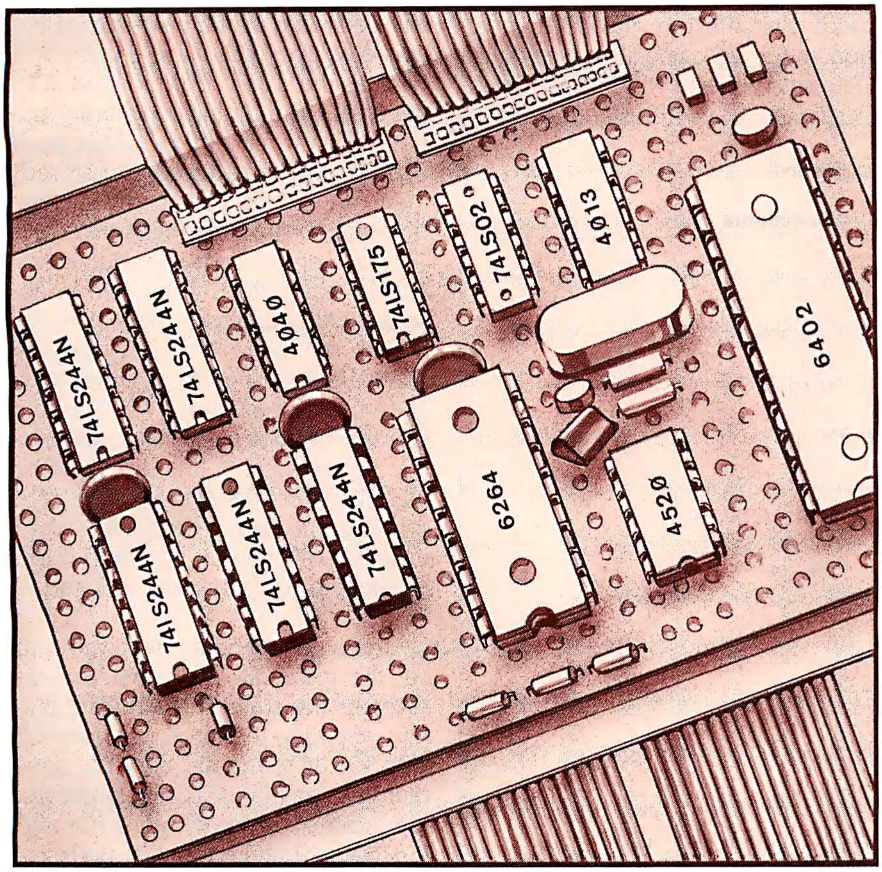


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Inquiry 296

BY STUART R. BALL

BUILD THE EMULO-8



A device that lets you develop EPROM *programs in* RAM

Are you tired of continually programming and erasing EPROMs as you develop software for your projects? How many EPROMs have you thrown away because they were programmed one too many times? The Emulo-8 solves these difficulties. The Emulo-8 is an EPROM emulator that interfaces to any computer that has an RS-232C serial interface. Software loaded into the Emulo-8 is executed in your target system as if it were in an EPROM. The Emulo-8, which can emulate 2716, 2732, or 2764 EPROM chips, is ideal for anyone who develops software for embedded microprocessors, especially if EPROM programming and erasing resources are limited. Firmware developed with the Emulo-8 needs to be programmed into an EPROM only once, after it has been completely debugged.

The normal method of debugging EPROM-based software is to erase and program a new EPROM each time a problem is corrected. This is tedious and time-consuming. It is possible to add enough RAM to a system to store the code, but this approach requires a ROM-based program to download the software and this also uses valuable printed circuit board space. Additionally, any time you run a program from system RAM, it is possible for a programming error to creep in and modify the RAM itself. The code will not work when it is programmed into an EPROM, although it works perfectly in RAM.

The ideal program-development tool, then, would use RAM that cannot be modified by the target system processor. It would have a simple interface to the host computer where

(continued)

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ILLUSTRATED BY TOM CENTOLA

the software is developed and plug into an existing EPROM socket to save space. The Emulo-8 meets all these requirements.

The Emulo-8 consists of an RS-232C interface, an internal 8K-byte by 8-bit RAM, and two DIP headers (24- and 28-pin). Data received from the host computer is stored in the RAM. The DIP headers plug directly into an EPROM socket on the target system. The address and data lines to the RAM are buffered by TTL gates that isolate the RAM from direct connection to the target system. The Emulo-8 has a self-contained power supply and does not need to be turned off while you make hardware modifications to the target system. (See table 1 for the parts needed to build the Emulo-8.)

HOW THE EMULO-8 WORKS

To load data into the Emulo-8, you switch it on and connect the RS-232C cable. Connect the appropriate DIP header to the target system. Place the mode switch (S1) in the LOAD position. In the LOAD position (see figure 1), tristate buffers IC4, IC5, and IC8 are disabled, and IC6 and IC7 are enabled. Set the address switches (S2 and S3) for the EPROM to be emulated and press the reset switch (S4) to reset the UART (IC10) and the RAM address counter (IC2). The Emulo-8 can now accept serial data via the UART. This data is loaded into the 8K-byte RAM (IC1). Data is sent to the Emulo-8 in binary format. The first byte received will be stored in location 0000, and each subsequent byte will be stored in the next successive address. The LED labeled A0 will blink as the data is downloaded. IC11 generates the timing for storing the data, as shown in figure 2. After each byte of data is received and stored, the RAM address counter increments, pointing to the next location.

If you set the address switches for a 2716, the data is contained in absolute RAM addresses 1800–1FFF. For a 2732, the data is stored in locations 1000–1FFF. Setting the switches for a 2764 uses the entire RAM. The actual storage locations are transparent to the target system and the loading logic. If you set the switches for a 2716 or 2732, the data is read and stored exactly as if the emulator had a 2K- or 4K-byte RAM starting at location 0000.

After all of the data is received, you set the mode switch to READ. This reverses the state of the tristate buffers, enabling the ones that were off (IC4, IC5, IC8) and disabling the ones that were on (IC6, IC7). The target system addresses the RAM via IC4 and IC5. Data is buffered via IC8. Both sets of buffers are disabled if the mode switch is in the center position, which allows both the host computer and the target system to be switched on and off without corrupting the data in the RAM or driving the bus of the target system. After placing the mode switch in the READ position, start the target system, and it will access the Emulo-8 in the same way it would an EPROM.

CONSTRUCTING THE EMULO-8

The circuitry, except for the power supply, is mounted on a single 3½- by

(continued)

Table 1: *The parts list for constructing the Emulo-8.*

Qty	Description	Comments
1	6264 8K-byte by 8-bit CMOS RAM	IC1
1	4040 12-bit CMOS counter	IC2
1	74LS02	IC3
5	74LS244	IC4, IC5, IC6, IC7, IC8
1	4013 CMOS 'D' FF	IC9
1	6402 CMOS UART	IC10
1	74LS175	IC11
1	4520 dual CMOS counter	IC12
1	7805 5-V regulator	IC13
1	SPDT toggle switch, ON-NONE-ON	S1 LOAD/READ
3	SPST slide switch	S2, S3, S5
1	SPDT momentary switch	S4, reset
13	10-kΩ, ¼-W resistor	
1	1-kΩ, ¼-W resistor	
2	2.7-kΩ, ¼-W resistor	
1	470-Ω, ¼-W resistor	
1	6.8-kΩ, ¼-W resistor	
2	33-kΩ, ¼-W resistor	
1	47-pF capacitor	
1	100-pF capacitor	
1	500-μf, 35-V capacitor	
1	100-μf, 16-V capacitor	
5	0.01 to 0.1-μF capacitor	Bypass capacitors
4	1N914 or 1N4454 diode	
1	1N4002 rectifier diode	Just about any > 1-A rectifier will work
1	2N2222A transistor	
2	LED	Just about anything will work
1	1.8432-MHz crystal	
1	DB-25S connector	
1	12.6-V transformer	Radio Shack #273-1385

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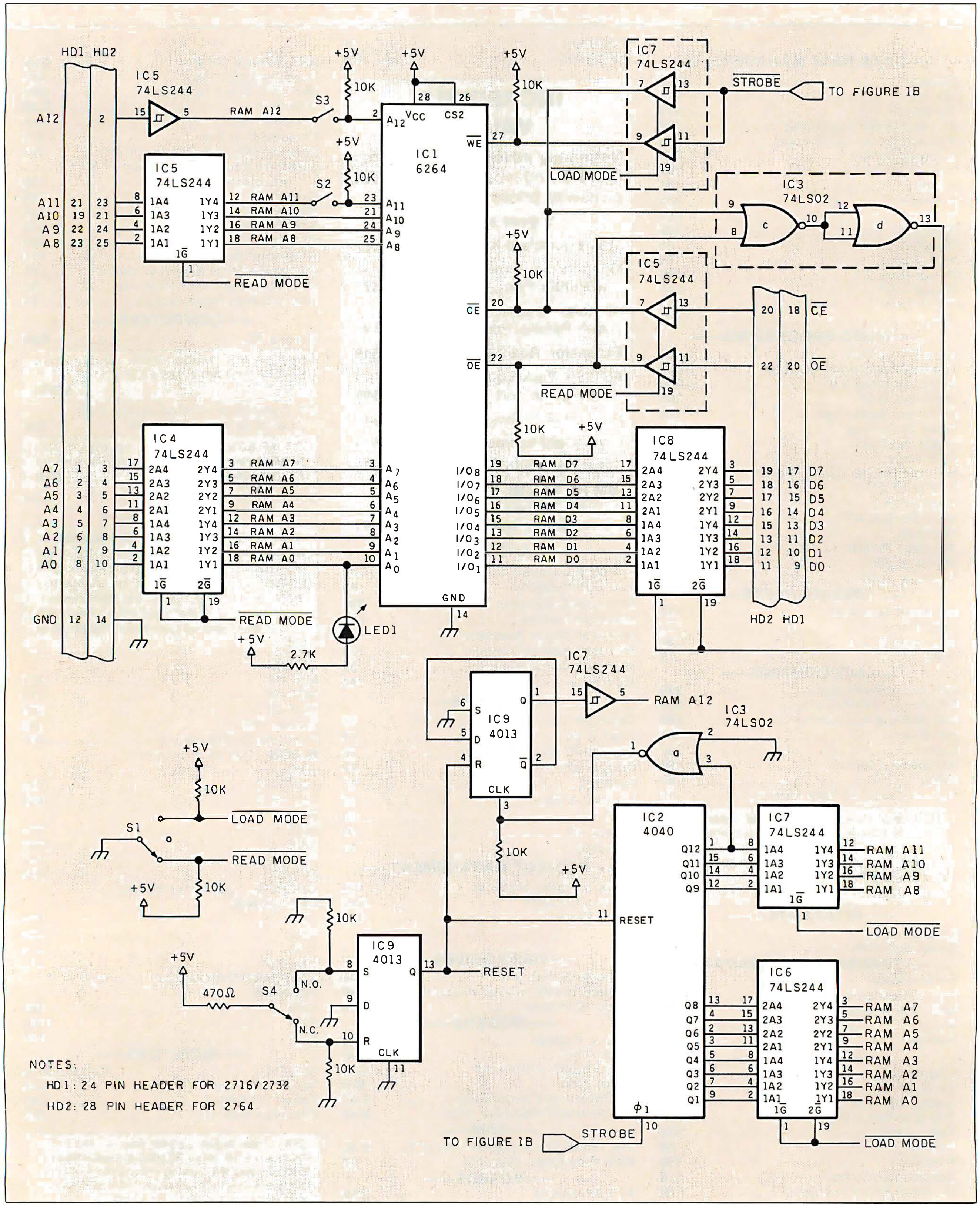


Figure 1a: *A schematic diagram of the Emulo-8.*

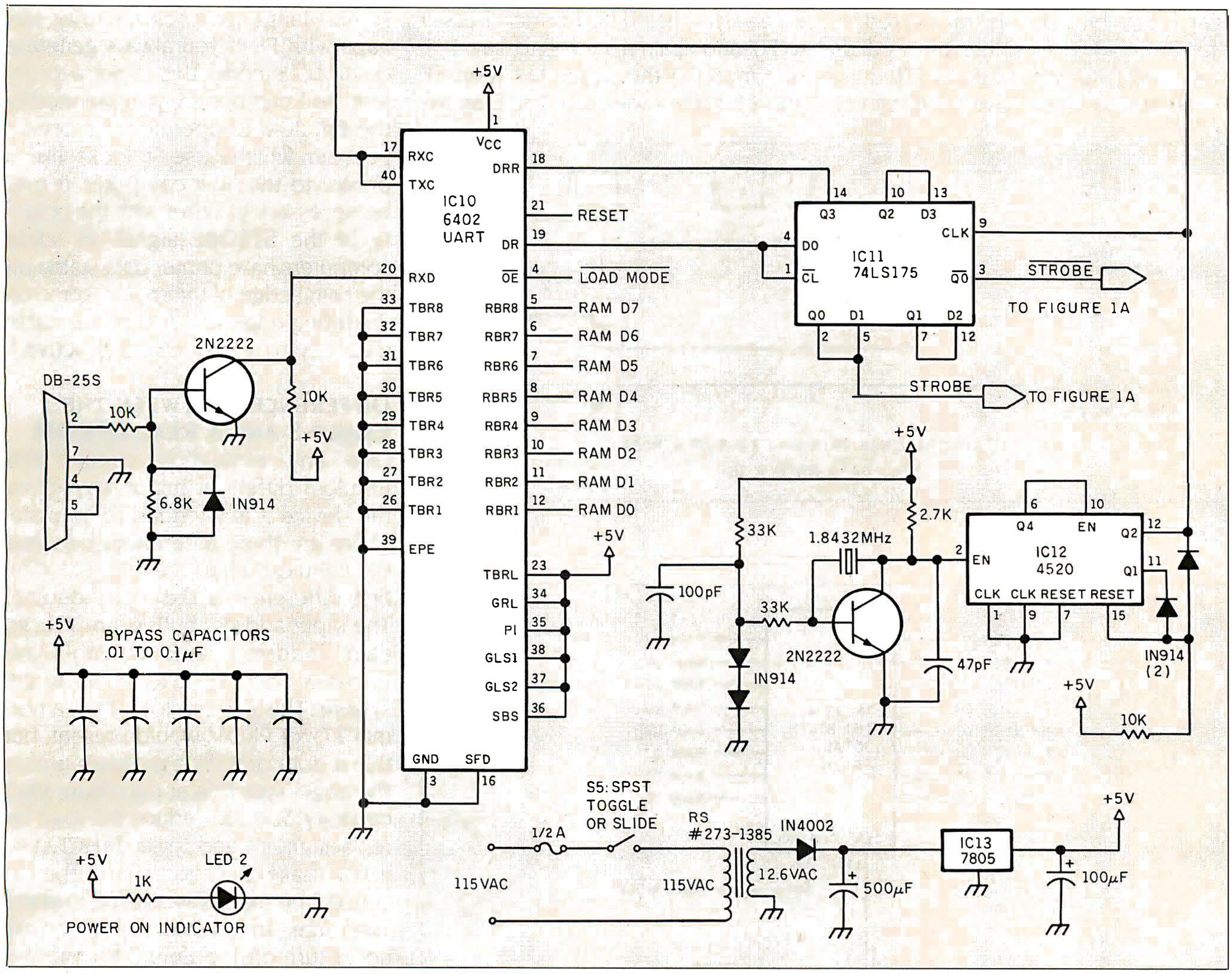


Figure 1b: *Serial interface circuitry and power supply schematic for the* Emulo-8.

5-inch perfboard. The circuit requires about 200 milliamperes of current at +5 volts. If you use the power supply shown, be sure to provide a good heatsink for the 7805 regulator. It is regulating 5 V from a 12-V transformer, so it dissipates more power than the rest of the circuit. You could substitute a 6.3-V transformer for the one shown, but the size of the filter capacitor must be increased. You can also substitute another power supply for the one shown.

The bypass capacitors shown on the schematic are essential, and you should distribute them evenly over the circuit board.

The 4520 counter (IC12) and the 1.8432-MHz oscillator generate the baud-rate clock for the UART. The connections shown allow operation at 2400 baud. You can generate other baud rates by changing the divide ratio. Use a metal can 2N2222A for the oscillator. Or you can replace IC12 and the oscillator with a baud-rate generator IC such as the MC14411.

The 6402 UART is connected for 8 data bits, 2 stop bits, no parity. To operate properly, the UART must be connected for 8 data bits. The number of stop bits and the parity can be adjusted to match your computer.

The DIP headers that connect the Emulo-8 to the target system are attached with ribbon cable. To avoid crosstalk, make every other wire in the ribbon cable a ground wire. If you have trouble locating 24- and 28-pin headers, you can build them. Do this by slicing a pair of 14- or 16-pin headers down the middle, cut off the extra pins, and mount them on a perfboard with plated-through holes.

If you do not have an 8-bit serial port on your computer, you can use the Emulo-8 with a (Centronics-type) parallel printer port. Replace the UART with a 74LS374 to latch the data, and use a 74LS74 to capture the strobe and return the BUSY signal (see figure 3).

Interfacing the Emulo-8

The Emulo-8 is intended to interface to an RS-232 port capable of transmit-

(continued)

ting 8 data bits. Data is transferred to the Emulo-8 in absolute binary format, and data gaps must be filled in. For example, if you have a file in Intel format that has data from address 0 to F0, and again from 100 to, say, 1FF, you must fill the space between F1 and FF with something. I use an assembly-language program that fills gaps with FF. If you always generate continuous code, this is not a problem. As I mentioned, you can modify the Emulo-8 to operate via a printer port, in which case it looks like a printer to the host computer. It may be necessary to tinker with the polarity of the STROBE signal, as some computers have printer data stable on the rising edge of the strobe, some on the falling edge, and some have stable data any time the strobe is active.

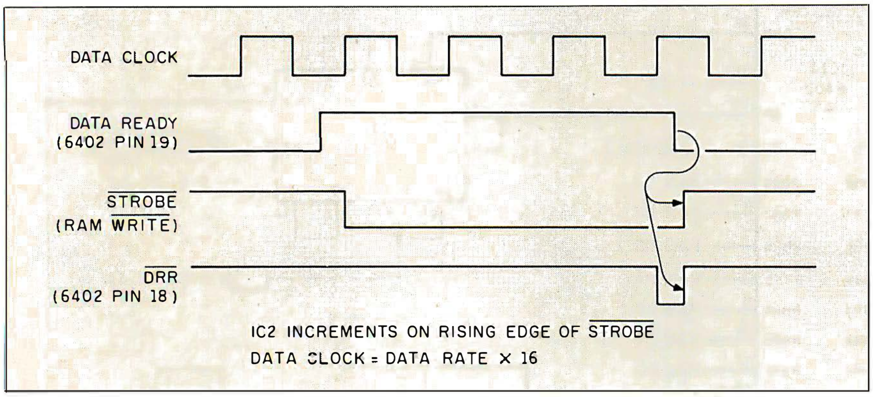


Figure 2: RAM *load timing.*

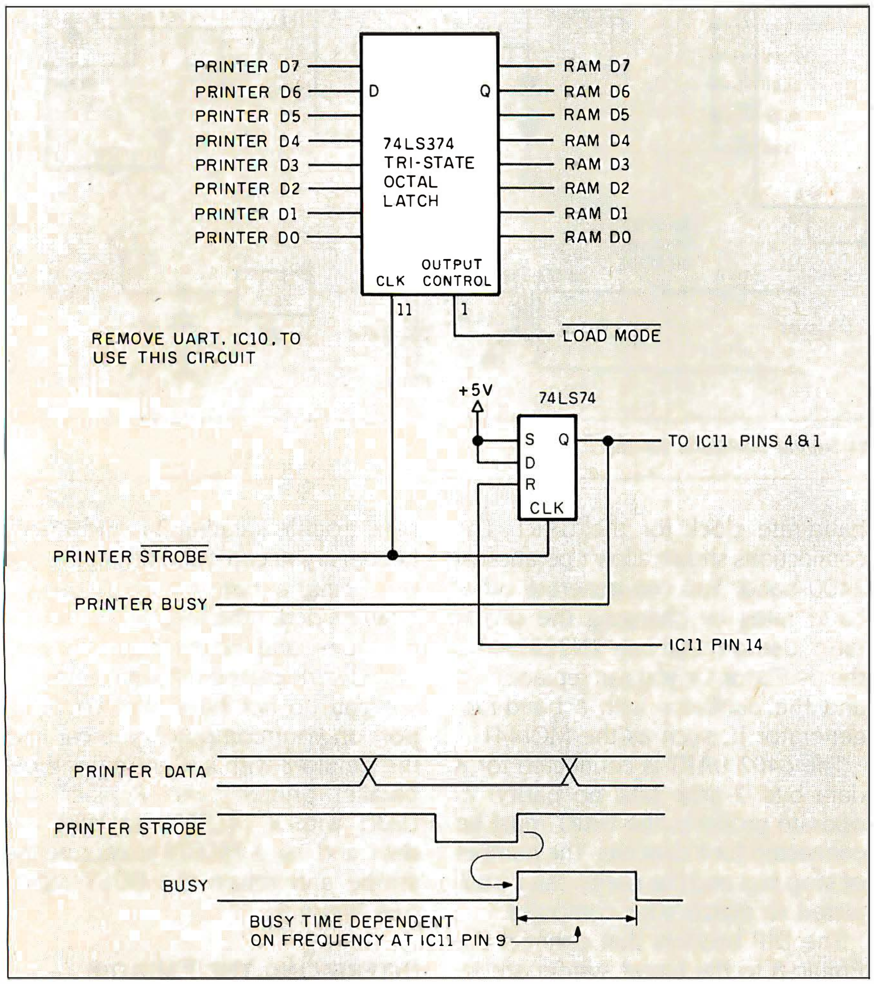


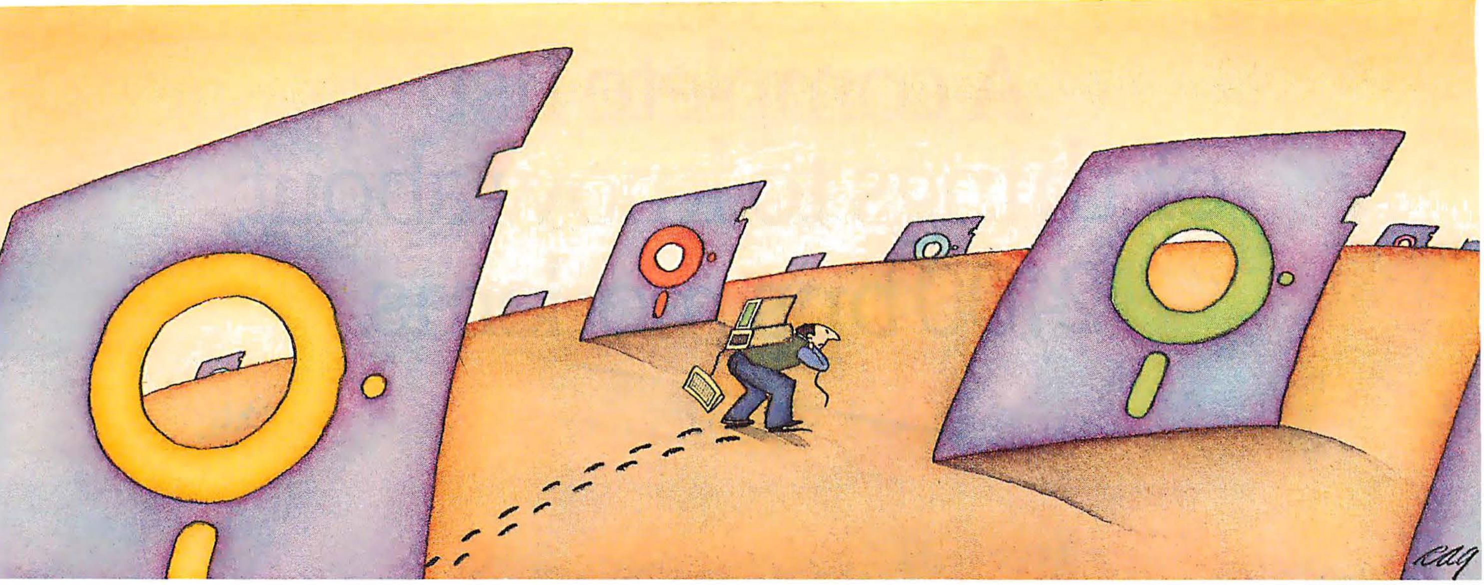
Figure 3: *Schematic for interfacing the* Emulo-8 *to a printer port with the load timing using the printer interface.*

Differences Between the Emulo-8 and a Real EPROM

Like any emulation circuit, the Emulo-8 differs in minor ways from the device it is intended to emulate. There are three differences between the Emulo-8 and a real PROM. The first difference is the input loading. The input address buffers are TTL, so each address and control line presents one TTL load to the target system. This is more load than a normal 27xx EPROM would present, but this is not normally a problem unless the target system is at maximum load capacity. You can reduce the load by replacing ICs 4 and 5 with 74HCT244s. If you make this substitution, the circuit will be more susceptible to static discharge. In addition, you should never turn off the Emulo-8 while the target system is turned on, or the HCT244s may latch up.

The second difference is the drive capability. The Emulo-8 data buffer, IC8, is a 74LS244, which has considerably more drive than a 27xx EPROM. The only consequence of this is that a heavily loaded circuit might work with the Emulo-8 but not with an EPROM.

The third difference is the access time. Most 8K-byte static RAMs that are available access much faster than a comparable EPROM. If the target system is designed around the access time of the Emulo-8 instead of the EPROM that will eventually be used, the circuit may not work when the real EPROM is installed. To avoid this, always design around the worst-case access time of the actual EPROM that will be used in the circuit. ■



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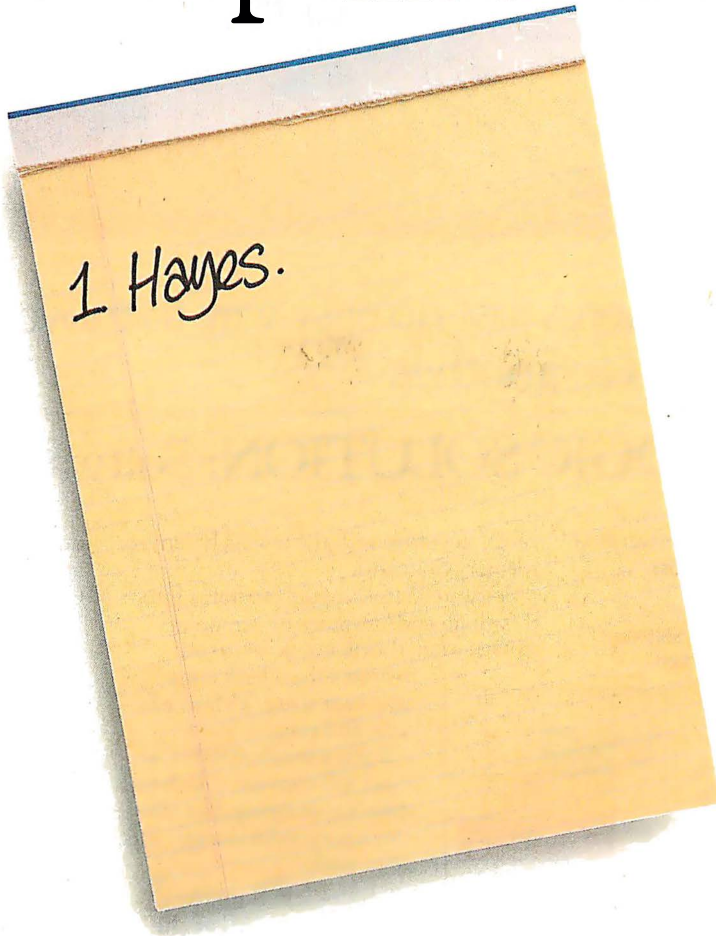
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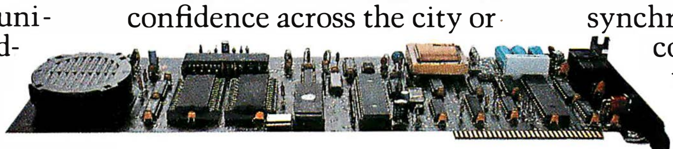
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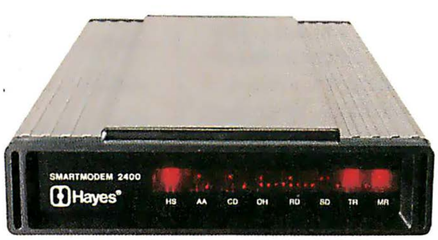
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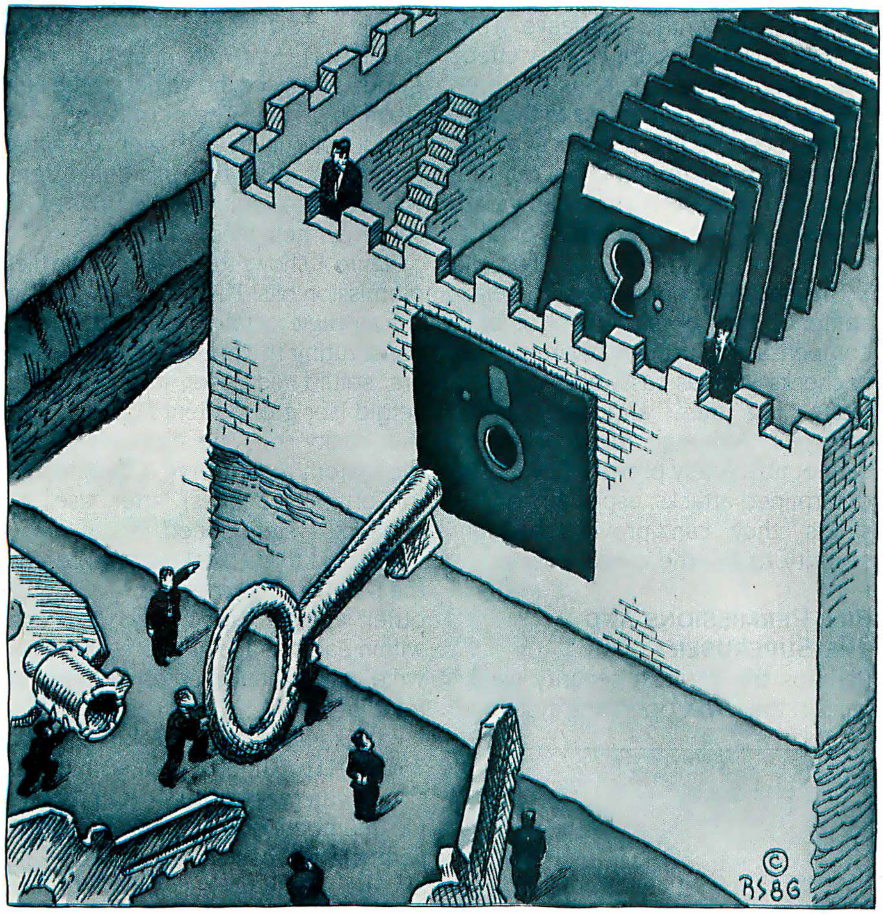
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BY ALAN FILIPSKI AND JAMES HANKO

MAKING UNIX SECURE



Countermeasures to known methods of attack

UNIX evolved as a powerful operating system at Bell Laboratories, where it was used primarily by a few research programmers. Much experience in using UNIX also came from universities, particularly the University of California at Berkeley. These environments provided an army of competent and dedicated hackers to test UNIX system security. UNIX operating system security has always been an "open book."

R. Morris and K. Thompson wrote the following in "Password Security: A Case History" (from the programmer's manual for UNIX System III, volume II).

> We did not attempt to hide the security aspects of the operating system, thereby playing the customary make-believe game in which weaknesses of the system are not discussed no matter how apparent. Rather, we advertised the password algorithm and invited attack in the belief that this approach would minimize future trouble. The approach has been successful.

In this article, we examine some specific security-related features of the UNIX operating system and discuss known methods of attack along with countermeasures and their associated costs. We make no claim of completeness; it is axiomatic that someone will always build a better

(continued)

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Both authors can be reached at Mail Drop DW160, 2900 South Diablo Way, Tempe, AZ 85282.

ILLUSTRATED BY ROB SAUNDERS

mousetrap (or Trojan horse).

We provide this information in a way that, we hope, is interesting and useful yet stops short of being a "cookbook for crackers." We have often intentionally omitted details. Admittedly, we are treading a thin line. However, it is the consensus of most system administrators that wider dissemination of such information is ultimately beneficial to the security of UNIX installations.

DEFINITION OF SECURITY

The level of "security" of computer systems can be measured by the amount of difficulty users would have accessing the system data or resources in a way unauthorized by the system administrator. The word "users" here includes legitimate users who modify or read data they are supposed to be excluded from, unauthorized persons who break into the system for the purpose of falsifying data or using system resources, or people who "decrypt" information they are supposed to read only in encrypted form.

We will not discuss protecting the user or administrator from his or her own carelessness or ignorance. If you are troubled by this kind of "insecurity" in a particular environment, you can write shell scripts or new shells to coddle the user to any degree required. Performing regular disk backups also effectively serves to limit the damage incurred in this way.

PHYSICAL VERSUS SOFTWARE SECURITY

There are two approaches to securing a computer system. You can put the system in a windowless electromagnetically shielded room with no data lines leading out and hire a guard to stand at the door and check persons who enter and leave. This type of physical security is very effective. Unauthorized persons are prevented from gaining access to the system and even legitimate users can be stopped from carrying tapes out the door. Of course, this approach greatly reduces the usefulness of the system.

The second approach is to relax some of this physical control and compensate by using software security checks, such as passwords, permissions, log files, and encryption schemes. Although these schemes cannot absolutely prevent clever and determined attacks, especially by insiders, they can provide enough security to foil the casual snoop.

FILE PERMISSIONS AND THE SUPERUSER

Perhaps the greatest security weakness of the UNIX operating system is the power of the superuser. There is no effective system of checks and balances against him or her.

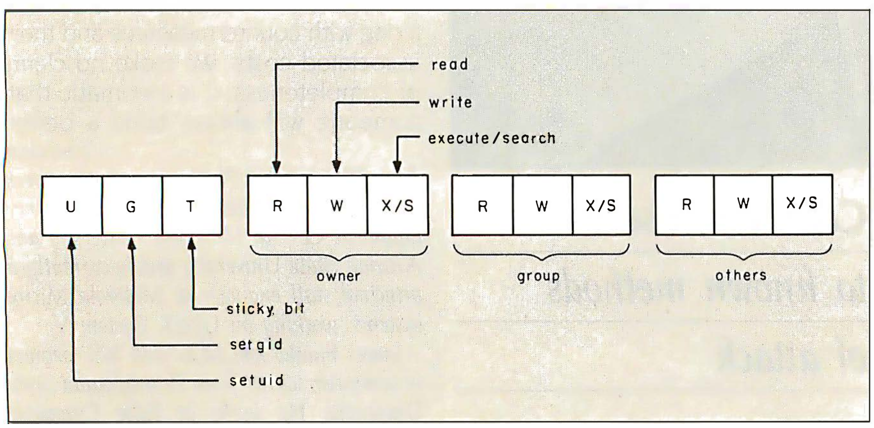


Figure 1: UNIX *file permissions. Under the* UNIX *operating system, a user's ability to access a particular file is governed by the setting of* 12 *bits (four octal digits) associated with that file. The high-order* 3 *bits are the* setuid, setgid, *and "sticky" bits, respectively. The remaining* 9 *bits represent* read, write, *and* execute/search *permissions for owner, group, and others, respectively.*

Within the UNIX operating system, each file has an owner and group associated with it and a set of switch values that control the way it may be accessed by different types of users. By default, the owner of a file is its creator, and the group associated with a file is the group its owner belongs to.

Only the owner of a file, or root (the superuser), can change the file's owner, group, or the values of the file-permission bits. The permissions are useful not only to the system administrator, but also to individual users who want to enhance the privacy of some of their files.

Figure 1 shows the format of the file-permission bits. They are organized as a four-digit octal number. The bits constituting the most significant digit are setuid (set user identification), setgid (set group identification), and the "sticky" bit. The sticky bit causes the system to preserve a core image (of often-used files) after use, to enhance system speed.

The next three octal digits represent the permissions for owner, group, and other users, respectively. The bits within each octal digit represent read, write, and execute/search permission for that group.

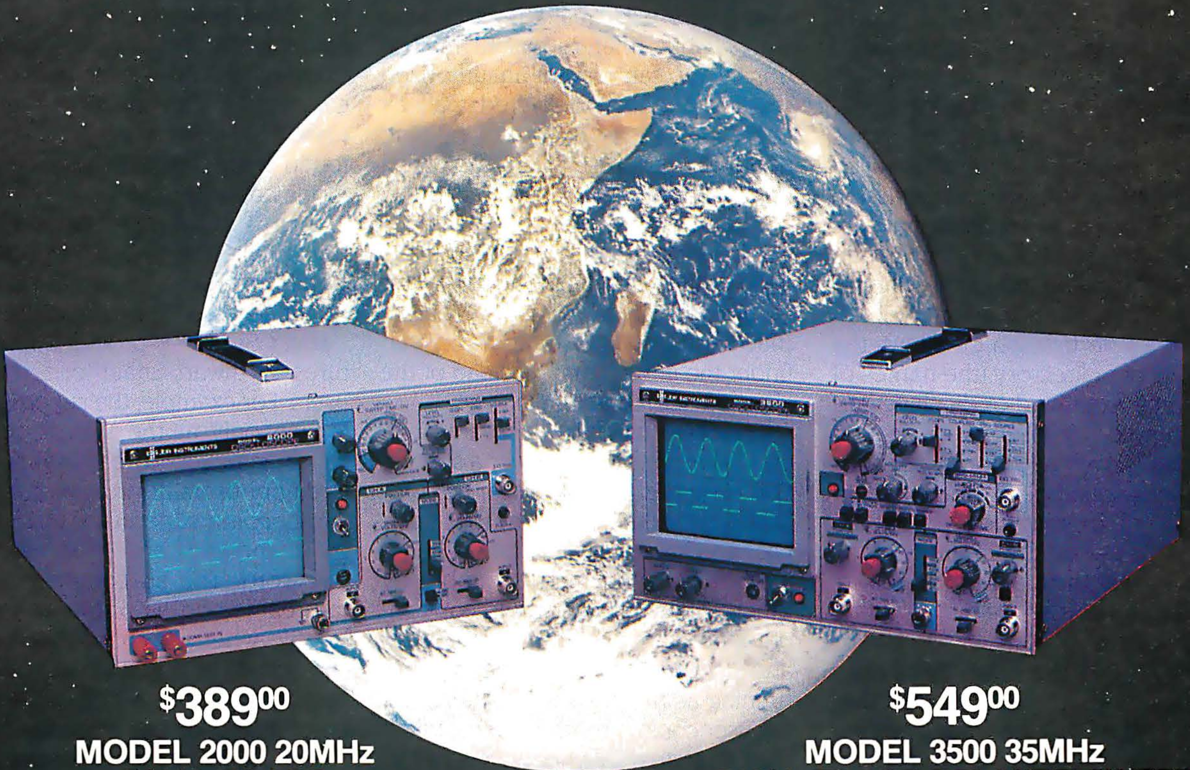
For example, a permission of octal 750 = 111 101 000 means that the owner can read, write, or execute the file; members of the group associated with the file can read or execute it; and others can neither read, write, nor execute it. A default set of values for these bits is used when a new file is created. Often this default is 644, meaning that only the file owner can write to and read the file, and everyone else can only read it.

In a work environment where people frequently need to share information, this is reasonable. But if security is a concern, the default should be changed to something more restrictive (such as 640 or even 600) and then weakened for selective files as necessary. UNIX's Bourne shell pro-

(continued)

PERFORMANCE

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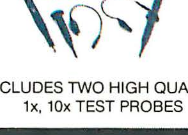
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vides an umask function to change this default.

Since directories are a special kind of file within the UNIX operating system, the same 9 permission bits apply to them. However, the execute bit has a special meaning here, and it is called the search bit. The search permission bit in a directory is required to access any file with that directory in its path. This is distinct and independent from read permission in a directory.

The read permission bit allows the contents of a directory (the names of files) to be examined or displayed as, for example, by ls. This distinction provides some additional security. You can let someone execute, read, or write to one of your files without letting him or her list the contents of the directory that the file is in. Therefore, the user can access the file only if he or she knows its name.

Some claim that the three-level (owner, group, other) file-protection system of the UNIX operating system is inferior to the scheme in which an explicit access list of users must be given for each file. Actually, you can simulate this other file-protection scheme on UNIX in several ways.

For example, you can form a group that defines any given subset of users, and you can give the desired permission to the group. More flexibly, a setuid program can be written to check the log-on ID of the user who invokes it and allow access to files based on a list of IDs. The UNIX SCCS (Source Code Control System) utilities do something like this.

Two additional file-protection bits, setuid and setgid, are very important to the security of the UNIX operating system. The setuid bit on an executable program allows it to run with the effective file-accessing power of the program's owner rather than with that of the user (the usual case). Likewise, the setgid bit on an executable program allows it to run with the effective file-accessing power of the group of the program file.

These features, when used with care, can be powerful tools for implementing application software. For instance, you can implement an electronic mail facility wherein a fictitious user group, e.g., "mail," is associated with all files that represent mail in transit. You can prevent unauthorized reading of the undelivered mail by preventing those users not running under the group "mail" from accessing the files.

This presents a dilemma: How does a user not ordinarily in group "mail" send mail to another? The setgid bit resolves this by allowing the program that sends mail to temporarily run under the group "mail" instead of the user's real group.

If not used carefully, this feature can compromise the security of a system. For example, the mkdir or df programs, which are owned by the superuser and have the setuid bit on, might inadvertently be made writable by others. Then any user could copy another program over the original mkdir and do whatever he or she desired, running as the superuser. Afterward, the user could copy the original mkdir back in to (partially) cover his or her tracks.

TRAPDOORS

The goal of nearly every UNIX system break-in scheme is to allow the cracker to become superuser (root) even for a few moments. The cracker creates a setuid shell that he or she can execute. He or she then becomes root whenever he or she wants to.

Administrators take note: A setuid root program in a user directory is an advertisement of a security hole.

If source is available on the system, the cracker can be more sophisticated. To cover his or her tracks the user creates a doctored version of, say, mkdir or df, and installs it in place of the real one. This version behaves exactly like the real one except that when given a special option, such as mkdir –xyzzy, it transforms itself into a shell via an exec system call. Since the original utility was setuid to root, the shell will be setuid root also.

The cracker now becomes superuser whenever he or she wishes, even if the superuser password is changed and the cracker leaves no incriminating programs in his or her working directory. The only trace left is that the doctored utility is now perhaps different in size and its modification date updated. But even these tracks can be covered. A little clever surgery can make the utility the same size, and touch can be used to reset its modification times.

Such a subverted utility is sometimes called a trapdoor because it gives those who know how to use it secret access to the operating system.

UNIX System V provides some features to thwart unauthorized superusers. For example, the superuser can log on only at the system console, which is subject to physical security. Ordinary users at ordinary terminals can become superusers through the su command and the superuser password. The su command enters the real log-on ID of the user into a log file when executed, but this log should not be relied upon as a deterrent because, like any other file, it may be changed by the superuser.

Because superuser privileges are required for many administrative operations, superuser passwords should be guarded with great care, should be changed frequently, and should never be given to anyone unless absolutely necessary.

THE crypt UTILITY

Many versions of the UNIX operating system provide a utility called crypt. This utility implements a single-rotor encryption machine that is a simplified version of the German World War II "Enigma" machine. Using the utility is simple—to encrypt an ASCII file plain to produce an encrypted file cipher, you only have to type

```
crypt [password] <plain> cipher
```

where password is a character string that serves as an encryption key. The crypt utility provides its own inverse, so that to decrypt the file, you type

```
crypt [password] <cipher> plain
```

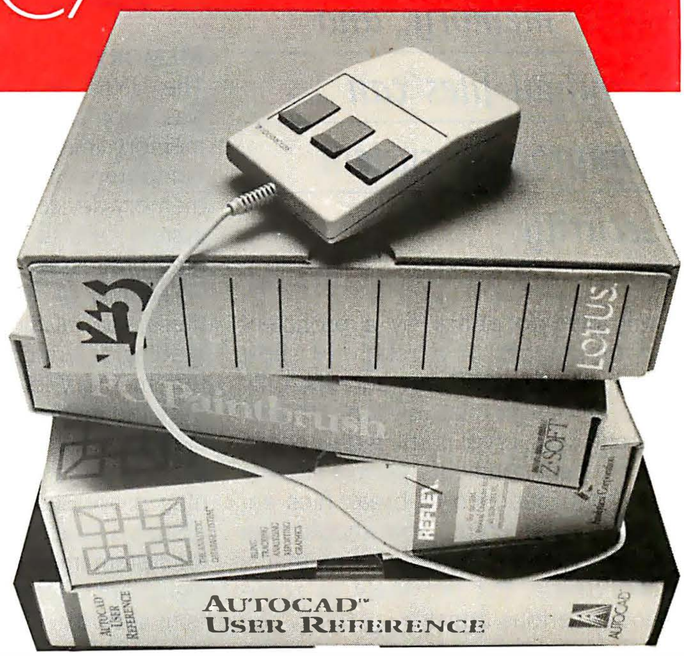
using the same string for password.

Recent studies indicate that crypt may not be as secure as previously thought and that the files produced

(continued)

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Device-special disk, memory, and terminal files can compromise system security.

will yield to attack by a proficient cryptographer in a relatively short time. However, if you encrypt only short files with relatively long (but different) keys, crypt is still fairly secure. In most environments, people lack the skill and patience to break files encoded with crypt. You should use crypt for encoding information that is confidential but not likely to come under serious attack.

Unfortunately, some versions of the UNIX operating system being produced today, particularly those designated for export, do not have a crypt utility. If your UNIX system does not have one, obtain a similar utility to provide a certain amount of security against casual attacks.

SPECIAL /dev FILES

Within the UNIX operating system, devices such as disks, terminals, etc., are treated as special files. These files appear in the directory /dev. For example, /dev/tty00 might represent a terminal and /dev/dk10 might represent one of the disks. Like any other file, each special file has an owner, a group, and a set of permission bits associated with it. If permitted, a user may perform read and write operations on it.

Internally, a special file is represented by a pair of numbers—the major device number (an index to a particular device driver) and the minor device number (one of the devices controlled by that driver).

Special files simplify the user interface to devices by allowing one mechanism to handle access to both devices and regular files. However, the use of three types of device-special files can compromise system security. The devices in question are memory, disks, and terminals.

MEMORY

The UNIX operating system kernel was kept small and simple due to memory limitations of circa-1970 minicomputers. Therefore, UNIX uses memory device-special files instead of system calls to report status of running processes.

Reading or writing a location in these special files has the effect of reading or writing the associated system memory location. The ps utility uses the memory device-special files to read the information in the system's process table and report about running processes.

Such a structure may be appealing for system implementation, but it is a nightmare in terms of maintaining system security. The memory device-special files provide a window into the running system through which any user's proprietary programs or data can be observed. Even worse, this window allows access to critical variables in the kernel itself. Ordinary users should never have read or write permissions on the memory device-special files.

DISKS

Disk device-special files provide a convenient method for system administrators to specify particular disks to be mounted, backed up, etc. Reading the information from such a file would reveal the disk data in "raw" form; i.e., blocks concerned with maintaining directory structures and raw data blocks would be mixed in a seemingly random manner. However, a sophisticated user with knowledge of the file-system structure could follow the disk pointers and read or write any information without regard to the permissions recorded for files. Again, care must be taken to assure that ordinary users do not have access to the disk device-special files.

TERMINALS

Terminal device-special files pose a special security problem in UNIX systems. Ordinary users need read and write permission on these files while they are logged on to the associated terminal, to allow them to use the write utility to send real-time messages to each other.

The problem is that users should not be allowed read permissions for terminals that they are not logged on to. Such access allows them to intercept data that is entered at the keyboard, including passwords.

Most UNIX implementations check access permissions on open calls only. Therefore, user 1 can start a background process that opens user 1's terminal for reading while he or she is logged on to it. User 1 can then log off, allowing user 2 to log on. At any time, the background process can issue a read and thereby intercept input from the terminal.

Although such an attack is hard to defend, it is easy to detect. The telltale symptom is that the background process, not the system, receives user 2's input, and it appears that the input line of data is lost. If the system indicates that user 2's password is incorrect but user 2 is fairly certain it was entered correctly, that password may have been intercepted. If this occurs, it is a good idea for user 2 to log on to another terminal and quickly change his or her password.

DIAL-UP LINES

Dial-up lines pose additional problems. For example, the UNIX System V user's manual advises you to terminate a session simply by hanging up the phone. This is a bad idea; the next user who dials in may be able to resume your session.

Call-back modems offer improved security but should not be relied upon absolutely. Persons knowledgeable about the workings of the phone system may be able to foil these.

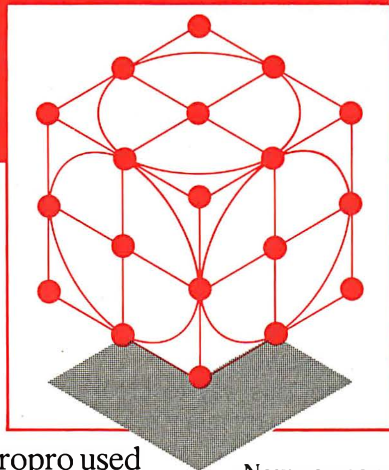
THE UNIX PASSWORD SYSTEM

Most time-sharing systems' passwords are kept in secret restricted files that ordinary users cannot read. The UNIX operating system takes a different approach. All passwords are stored in

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encrypted form in the file /etc/passwd, along with other information in plain form, such as log-on IDs, home directories, users' names, etc.

All users can read this file. This is the only place on the system where passwords are kept. Passwords are never stored anywhere in plain unencrypted form. However, the exception to this rule is the uucp file (L.sys, which we will discuss later), which contains passwords for restricted access to other systems.

No means are provided for decrypting the passwords in /etc/passwd, even by the superuser. If you forget your password, you cannot have the superuser find out what it is; you can only ask him or her to change it for you.

THE /etc/passwd FILE

Figure 2 shows a typical /etc/passwd file entry and defines the individual data fields within it. The system administrator can add new entries simply by editing the /etc/passwd file.

System administrators, please take note: Never set up log-on IDs with null passwords. This is sometimes done at universities where student accounts are set up without a password entry in /etc/passwd. The intention is that the student can supply it the first time he or she logs on. Anyone can peruse the /etc/passwd file looking for accounts with null passwords and commandeer those accounts.

ATTACKS VIA THE /etc/passwd FILE

One obvious way to break into the system is to try many passwords until you find one that works. You can do this by trying to log on many times with passwords generated combinatorially or read from a dictionary or list of proper names. A disadvantage to this method is that log-on programs are often intentionally slow and sometimes record a log of unsuccessful log-on attempts.

In a variation of this approach you encrypt trial passwords and compare the resulting strings with the encrypted strings in the publicly readable /etc/password file.

A number of UNIX security features make this type of search impractical. First, UNIX uses an iterated version of the DES (Data Encryption Standard) algorithm that is unavoidably slow when implemented in software. The password encryption library routine crypt( ) (no relation to the utility crypt) requires about 1.29 seconds of VAX-11/780 processor time to encrypt a single password. This is fast enough so that a legitimate log-on sequence does not take an inordinate amount of time, but an exploratory key search would.

To prevent you from using commercially available hardware (e.g., DES chips) to perform a key search on a password file, the UNIX software uses a DES version with some minor modifications. Figure 3 and figure 4 illustrate the use of the modified DES algorithm for password encryption and verification, as adapted to the UNIX operating system.

The fields within the entry are separated by colons.

al :	davRP5LxxmSP.,90/A :	112 :	20 :	AD446-3570-AlFilipski(2000) :	/a/a1 :	
1	2	3	4	5	6	7

Field 1 is the log-on name of the user.

Field 2 is the password field:
- The first 11 characters, davRP5LxxmS are the encrypted password.
- The next two characters, P., are the salt.
- The comma is a subfield separator.
- The 9 and 0 following the comma mean that the password must be changed no less often than every 9 weeks and no more often than every 0 weeks.
- The /A is an encoded count of when the password was last changed, in weeks, since the beginning of 1970.

Field 3 is the numerical user ID.

Field 4 is the numerical group ID.
It is a key into the field /etc/group.

Field 5 is a comment field and can contain administrative information.

Field 6 is the user's home directory.

Field 7 is the null last field. It indicates that the user's default log-on shell is /bin/sh.

Figure 2: *A typical* /etc/passwd *file entry. The fields within the entry are separated by colons.*

salt

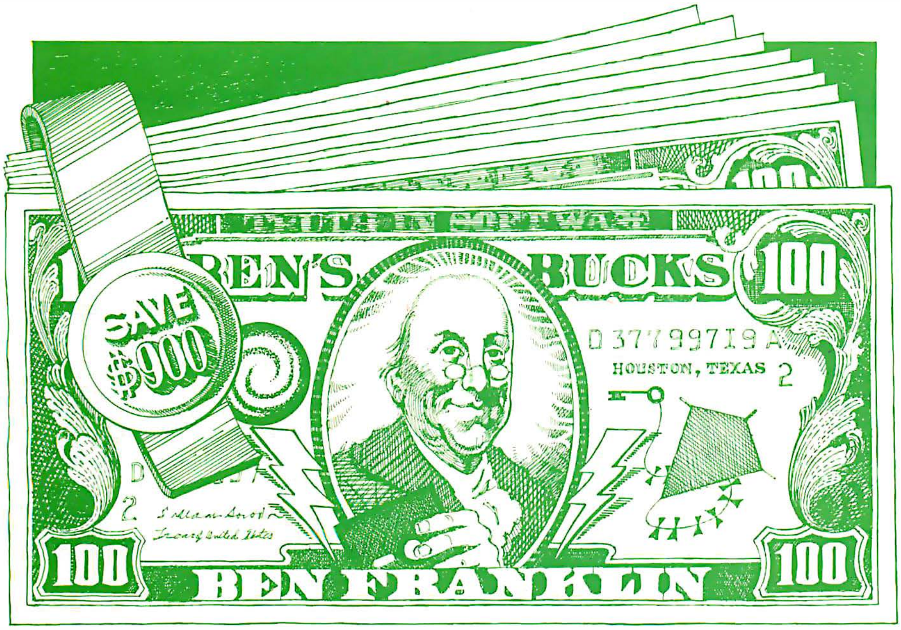
Another security feature that makes a key search impractical is the use of salt during password encryption. The new password utility obtains a random two-character string (the salt string) from the environment. Actually, this string is a function of the current time and process ID number (PID).

Twelve bits of this salt string are then used to modify, in one of 4096 different ways, the DES algorithm that encrypts the password string given by the user. The salt is stored in the /etc/passwd file along with the encrypted password. When a user enters a password at log-on time, the salt string from his or her entry in the /etc/passwd file encrypts his or her password.

Use of the salt string enhances password security in several ways. First, even if two users happen to choose the same password, their /etc/passwd entries will almost always look completely different. This prevents a user

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from making efficient sequential searches of the /etc/passwd file to see whether anyone is using a particular password. Determining if any of 100 people have the password 23skidoo, for example, requires 100 separate applications of the encryption algorithm.

Finally, the UNIX operating system imposes many restrictions on the length and composition of the passwords. For example (under UNIX System V, release 2), passwords cannot be either entirely numeric or entirely alphabetic. This discourages the use of strings that can be easily guessed, such as people's names. A password aging system is also implemented so that users can be automatically forced to change their passwords periodically. This feature should be used!

System V also provides the option of specifying a *minimum* length of time a password must exist before it can be changed. This feature is of questionable value. We recommend that it be set to 0 but that users be educated about the foolishness of using this to maintain the same password perpetually.

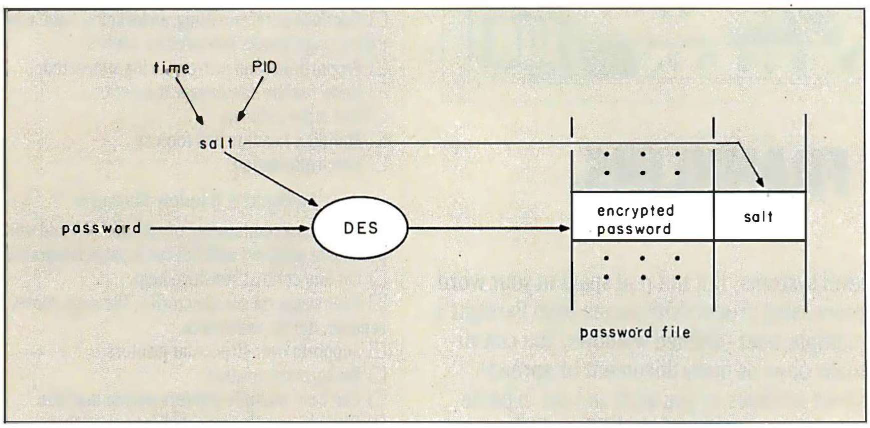


Figure 3: UNIX *password encryption. When the user enters a new password, it is encoded by a variant of the* DES *algorithm. The algorithm is modified in one of* 4096 *different ways by a random quantity called the* salt, *which is then stored in the file* /etc/passwd *along with the encrypted password.*

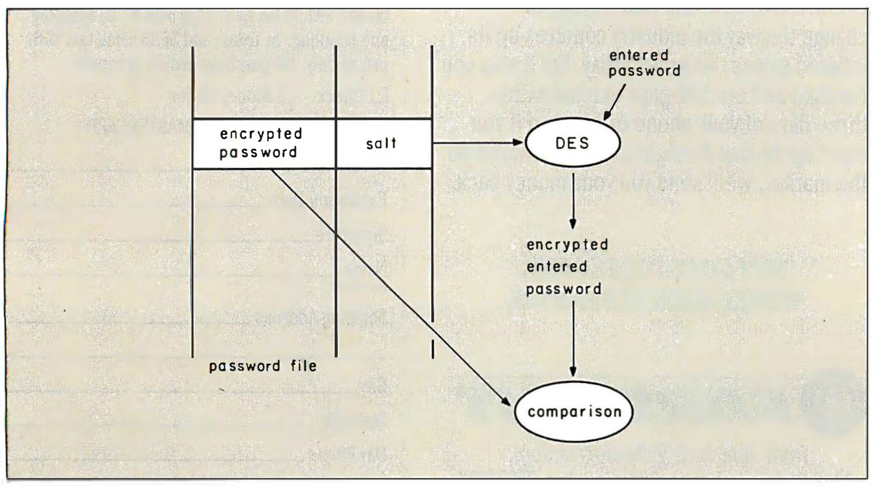


Figure 4: UNIX *password verification. The entered password is encrypted by a variant of the* DES *algorithm using the* salt *string readout of the* /etc/passwd *file entry for that user. The resulting encrypted password is compared to the encrypted password in the file. If they are the same, the password is accepted. Note that the password in the file is never "decrypted."*

THE TROJAN-HORSE PRINCIPLE

The cracker's Trojan-horse principle consists of getting a legitimate user to unwittingly execute or utilize program code set up by the intruder. Sometimes the planted code looks like an ordinary system utility. If the duped user happens to be a superuser, the security game is effectively over because it takes an intruder only a few instructions (as superuser) to set things up so that he or she can effectively become the superuser whenever he or she wishes.

For example, the intruder can quickly install a modified version of the su utility that bypasses the password check and log-file entry when a certain argument is given. Here are some of the more common ploys based on the Trojan-horse principle and some possible countermeasures for each.

FISHING FOR PASSWORDS

One technique uses a program that simulates the log-on sequence of the system. The intruder leaves this program running on a terminal that appears to be unused. When another user attempts to log on, the program easily dupes him or her into revealing his or her password. The password is then written into a file owned by the intruder, the password program kills itself, and a real log-on sequence is initiated.

A fishing program can be made sophisticated enough that users never know their passwords have been compromised. However, one feature of these programs arouses suspicion. After the fishing program obtains a password and writes it to a file, it must make a graceful transition to the real sequence for logging on.

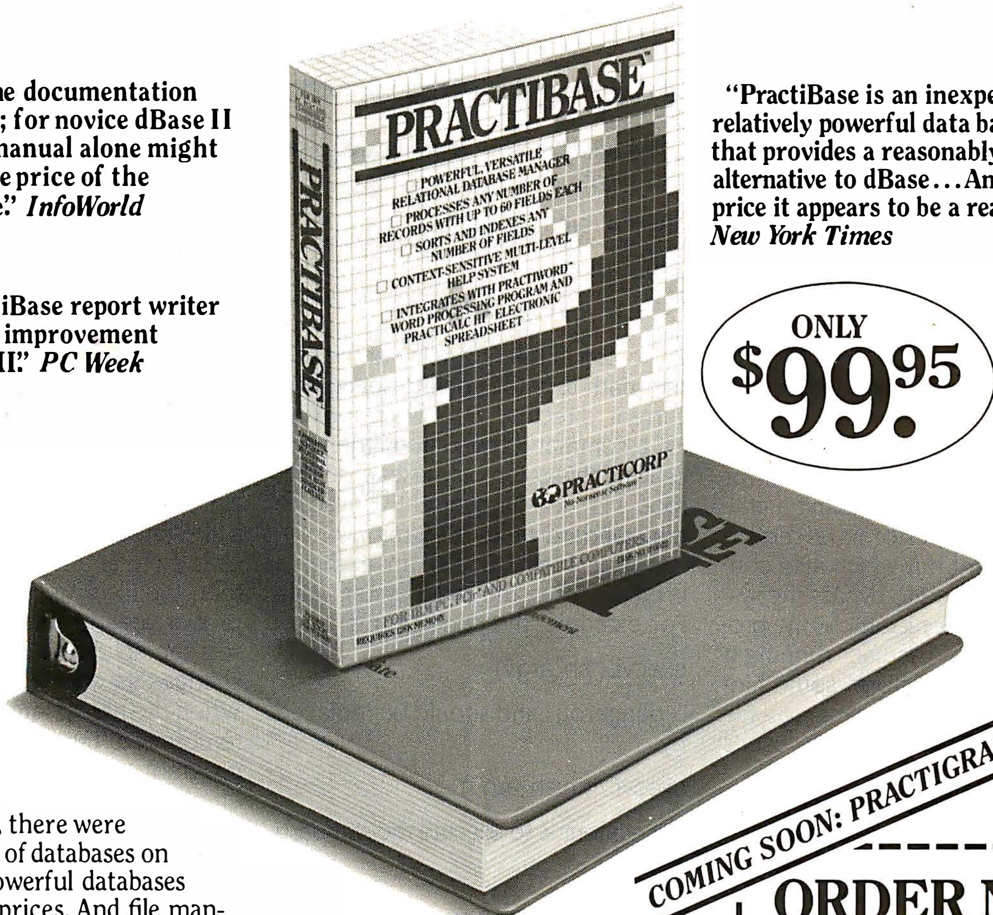
The giveaway is that the user has already given his or her password correctly once yet must enter it again for the benefit of the "real" log-on program, which requires that the password be entered from a terminal. The fishing program usually tries to disguise this requirement by claiming

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that the password given is "incorrect." Therefore, whenever you are fairly sure that you have entered your password correctly but the system says that it is incorrect, it is a good idea to log on to another terminal and change your password immediately.

FAKE UTILITIES

Many installations have a directory where locally produced utilities can be placed. Often, users will include this directory in their path variable, which indicates where to search for commands. A user may submit a utility program that performs a service many users want but which also contains code designed to bypass the system protections. For example, the program can check if the user running it is root and, if so, perform some hidden operation, such as changing a file to setuid root, without the user's knowledge.

In a simpler method, the user places a program in his or her directory with the same name as a commonly used system command, such as ls. If another user, including root, executes this program instead of the real ls utility, the user will be at the mercy of the fake utility program.

The system administrator can limit his or her vulnerability to these attacks by keeping the current directory and any local utility directories out of the path for root.

The utility su should take care to set root's path to

PATH = /bin:/etc:/usr/bin

rather than

PATH = :/bin:/etc:/usr/bin

The colon at the beginning of the second path tells the shell to search the current directory first when looking for a command typed in by the user. Leaving this colon off makes sure that root will not inadvertently execute nonstandard utility programs.

This problem can also arise when a program uses the exec system call. For example, the code segment

execvp("sh",argv)

is dangerous and should be replaced by

execv("/bin/sh",argv)

if the intent is to execute the standard shell.

FAKE DISTRIBUTIONS

A remarkably simple and bold way of installing a Trojan horse in a system is to mail a doctored distribution tape to the system administrator with the return address of the source of the distribution tapes on it. The intruder wants the administrator to believe that the tape is an ordinary update and install it on the system. Therefore, the perpetrator of this ruse must know a considerable amount of inside information. The security-conscious administrator should be aware of this possibility.

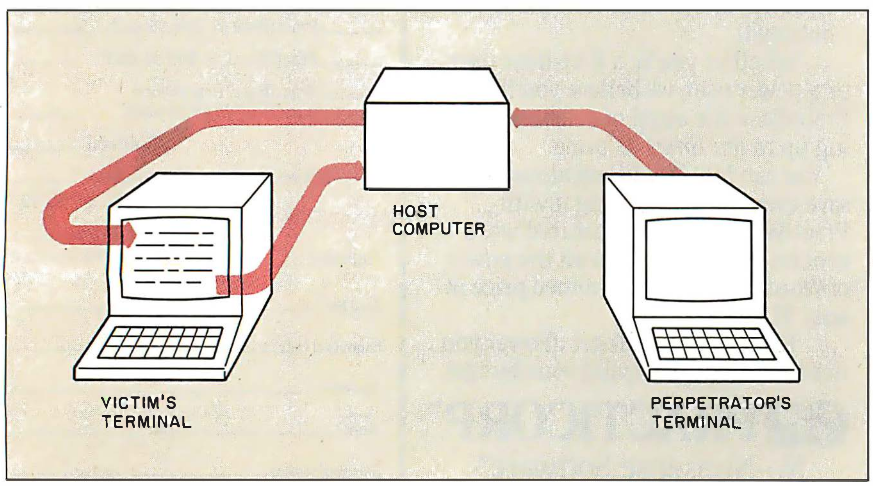


Figure 5: *Terminal page-mode buffering. The colored path indicates how the perpetrator can send his or her own commands to the victim's terminal and then to the host, where they are interpreted as commands entered by the victim. Terminals with this feature should not have* write *permission for "other" enabled.*

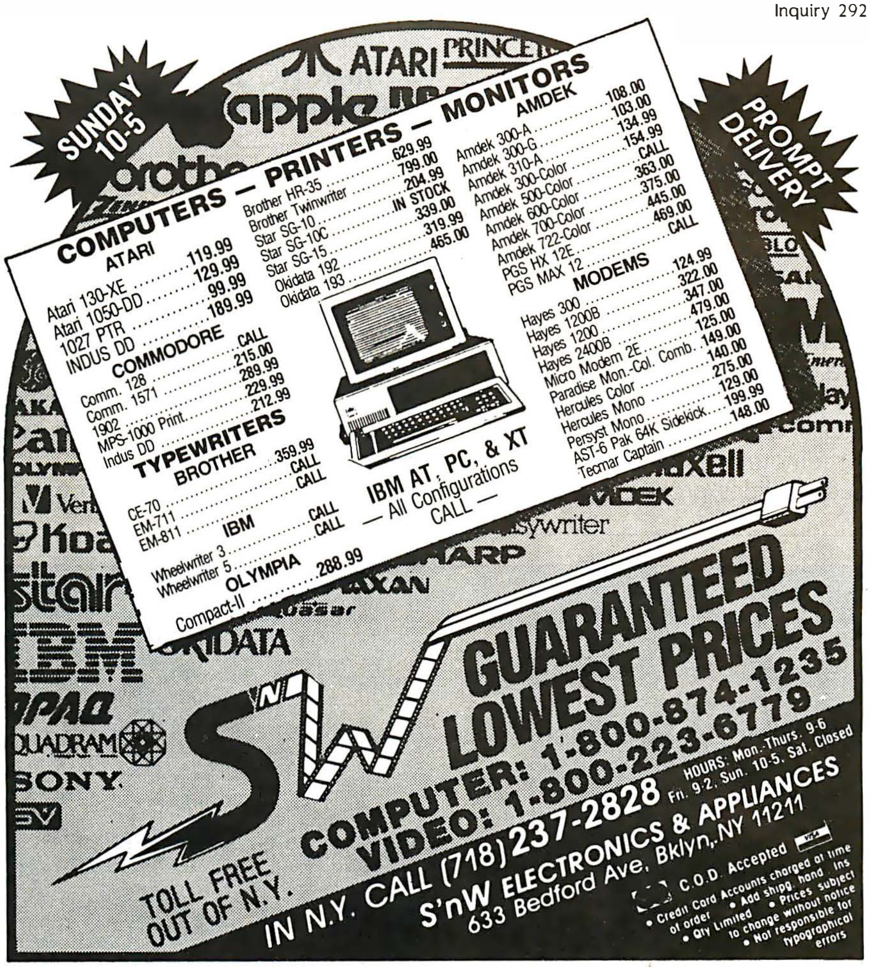
MOUNTING A DOCTORED FILE SYSTEM

The UNIX operating system accepts the contents of a mounted file system as being completely accurate. However, it is possible for a user to create a file system on removable media. The user then, at another location, "doctors" the file system. By writing to the proper area on the media, the user sets the setuid bit on a program and changes its ownership to superuser. When the file system is subsequently remounted, the user runs his or her program as the superuser. The most effective control of this is to restrict physical access to the machine and media.

OTHER TECHNIQUES

Another technique involving user terminals is terminal page-mode buffering (see figure 5). Most moderately intelligent terminals have what is known as a page mode of operation. When the terminal is put into this mode (by certain escape sequences), it does not send information to the host but merely buffers it in screen memory. When the terminal receives certain other escape sequences, it sends the contents of its buffer to the host computer.

All of these operations can be performed by sending escape sequences (from the host) instead of typing them in at the keyboard. The cracker makes the system believe that commands he or she writes to the victim's terminal were really entered by the victim. (Under the UNIX operating system, a terminal is simply a special file and you can usually write to it for the purpose of real-time communication via the write command.) Any processes the commands invoke therefore run under the victim's user ID. The efficacy of this method depends on the ter-



minal used; there may be some visible effect, such as a flash at the victim's terminal.

How can this type of attack be guarded against? Terminals should be provided without the page-mode feature or at least with the option of turning it off. Making your terminal nonwritable to others is easy—just type mesg -n. However, this does not provide certain protection against this trick, since mail or other means may be used to manipulate your terminal.

Attacks by Hogging Resources

The UNIX operating system evolved in a nonhostile environment and is relatively liberal in its granting of resources to a user. Typically, a user is allowed to run 25 concurrent processes, and each process can have 20 files open simultaneously.

These limits, in isolation, will not cause the system trouble and are generally more than enough for any legitimate use. However, in order to limit the amount of memory the kernel occupies, installations often limit the number of files open (systemwide) to around 250. This is also generally enough for even a heavily used system.

A problem arises, however, when a malicious user spawns 25 concurrent processes that each attempt to open 20 different files. The user quickly takes all available slots in the file table and essentially makes the system unusable by others. UNIX installations that might encounter such antisocial users should be adjusted to prevent any single user from causing such problems.

Another area of concern is disk-storage space. Although the size of a user's files is usually limited to 1 megabyte, typically there is no limit to the number of files a user can produce. (Or if there is, it is often only enforced at the time of logging on or off.) Therefore, it is possible for a user to allocate all the free blocks of a file system to himself or herself, resulting in irate users and possible damage to the file system. However, the damage

(continued)

is usually minimal and easily repaired.

ATTACKS VIA uucp

The uucp family of utilities facilitates file transfer between different UNIX sites and also provides the capability for remote command execution. The uucp utilities provide a good set of security features to restrict the set of files and commands the remote user has access to, but they make up a complex system with many nooks and crannies and must be administered properly. The following security points must be observed carefully when setting up uucp utilities.

The uucp family allows the administrator to give a different log-on ID and password to each authorized remote-user system. Do this. Under no circumstances make this log-on ID the same as that of the uucp system administrator. Put all remote users in a single group that is used for nothing else. This information should be included in the /etc/passwd file.

Make sure that uucp log-ons do not get the standard shell. They should get the program uucico, which implements all the security restrictions of the uucp system. Also, their home directory should be /usr/spool/uucppublic. This log-on shell and directory are also included in the /etc/passwd entries for the remote users.

There is a file called /usr/lib/uucp/USERFILE that allows the administrator to specify, for each remote user, which UNIX subdirectories he or she will be allowed to copy files to and from. This check is in addition to the normal file-permission scheme, so that even if a file can be read by others, if it is not in one of the proper subdirectories, the remote user will not be allowed to uucp it. It is a good idea to prevent all uucp access to directories other than /usr/spool/uucppublic.

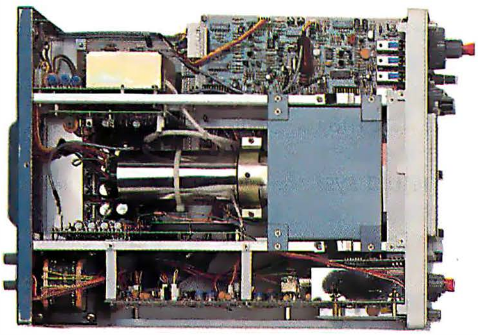
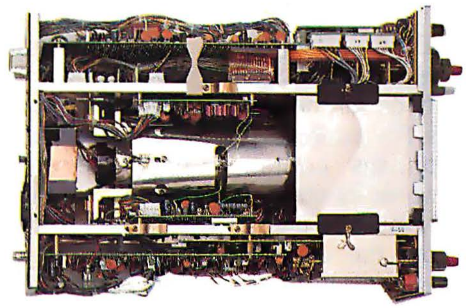
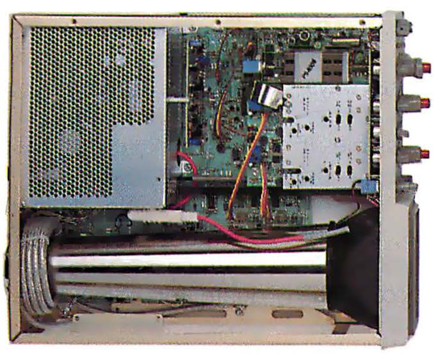
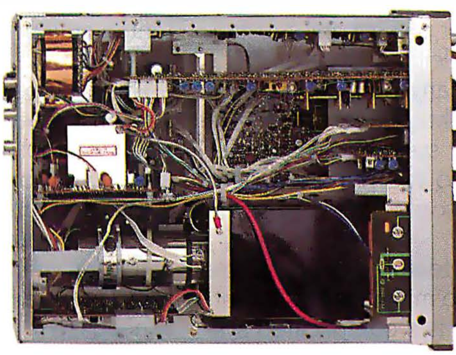
The uucp utilities provide a file that the administrator uses to specify which commands can be executed from a remote system. Do not put commands in here without a reason. For example, rmail (not mail) probably should be in here, while chmod probably should not.

Use the sequence-check feature, which keeps a sequence count of conversations with particular systems. If the sequence number given by the calling system is not what the called system expects, the conversation is disallowed. This prevents someone from masquerading as a particular remote system even if he or she knows the log-on ID and password assigned to it.

Use the call-back feature where appropriate. When this facility is set up in uucp, incoming calls are told: "OK, now I know you want to talk; I'll call you right back." This requires the

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caller to be at the phone number that the called system knows as his or hers. The call-back feature may be specified for a remote system by setting a flag in that system's entry in the file /usr/lib/uucp/USERFILE.

Finally, make sure that permissions are set up properly on all the uucp administrative files. For example, the file /usr/lib/uucp/L.sys contains numbers and passwords for other systems and obviously must be unreadable by anyone but the uucp administrator. In general, it is necessary to set the permissions of the uucp files with extreme care.

If the above precautions are taken, uucp should not present any substantial security hole in a UNIX installation. However, any outside line to a computer slightly decreases the security of the system. An intruder who breaks into the remote system can now have some access to yours as well.

The security features of uucp are well designed to minimize this threat. However, uucp is a complicated system that no doubt contains security holes that have not yet been discovered or plugged. For example, ways have been suggested to induce uucp to create files whose owner is the uucp administrator but whose content is determined by some other user. Such a file may then be executed to gain access to sensitive information in /usr/lib/uucp. The uucp facilities provide a favorite hunting ground for crackers, and the security-conscious administrator would be well advised to keep an eye on it.

Attacks via Mail

To facilitate communication among users, the UNIX mail system is set up as belonging to a mail administration group, with /bin/mail a setgid program. The text of all mail sent is kept in a central location (the directory /usr/mail in System V) and can be read and written to by anyone in the group mail.

As with any setuid or setgid program, mail must be carefully administered. Clearly, it would be disastrous to allow a user to create his or her own setgid mail program, for example, by writing over /bin/mail. Such a program could be used to read or forge mail.

Some common versions of the mail utility allow a user to easily forge a false signature on mail sent by him. This is a very serious defect. The mail program should determine the identity of the sender via the getuid system call and not rely on other (possibly faked) means of identification.

Preventing the Damage

The greatest security weakness of the UNIX operating system is the power inherent in root. Therefore, an important overall principle is to *minimize the use of* root.

This may be done in several ways. First, use specialized log-on IDs instead of root whenever possible. If user ID bin or nuucp suffices to do a job, don't use root.

Second, make judicious use of setuid programs in lieu of giving out root. For example, if a user occasionally needs to mount a particular file system, having a program that is setuid to root is preferable to giving out the root password and is more convenient than having the user request that the system administrator provide this service.

Finally, and perhaps obviously, change the root password frequently.

Undoing the Damage

What can a system administrator do if he or she suspects that someone has broken root? There are several kinds of traces that an inept or casual cracker may have left behind. The utility su maintains a log of uses or attempted uses. Programs that are setuid to root can easily be discovered using the find utility.

For example, the following command prints out the path names of all files on the system that are owned by root and have the setuid bit set:

```
find / -perm -0004000 -user root -print
```

(On some systems, the ncheck utility may be used for the same purpose.) Finally, if the perpetrator has avoided these means of detection, it is possible to modify the kernel to print out a secret log of superuser activity to a file or to the console.

Ridding the system of all effects of a hostile superuser is a big job. Essentially, the system needs to be generated again from known secure sources. Special attention needs to be paid to all setuid programs.

Costs and Requirements

There are many steps an administrator can take to prevent attacks. Many of these precautions are free. However, some security measures cost money, efficiency, or ease of use of the system. You must make an intelligent evaluation of the real security requirements of a particular installation before you establish a security program.

Conclusion

Some people claim that the UNIX operating system provides no security. While it is true that UNIX is inadequate for some types of classified government projects, so are most other operating systems.

We have outlined some security threats to the UNIX system and their related countermeasures. An administrator who is aware of these methods can maintain a UNIX system installation that provides a sufficient degree of privacy and protection for most applications. ■

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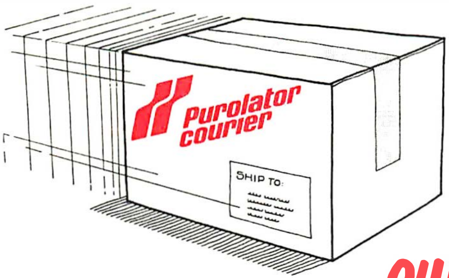
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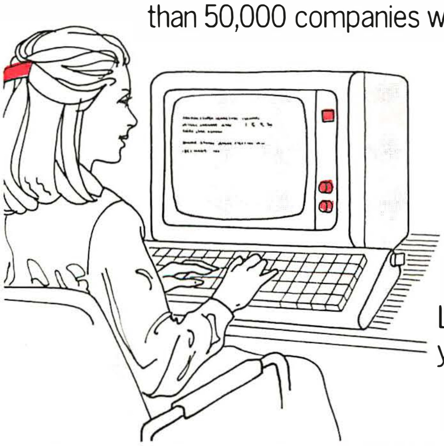
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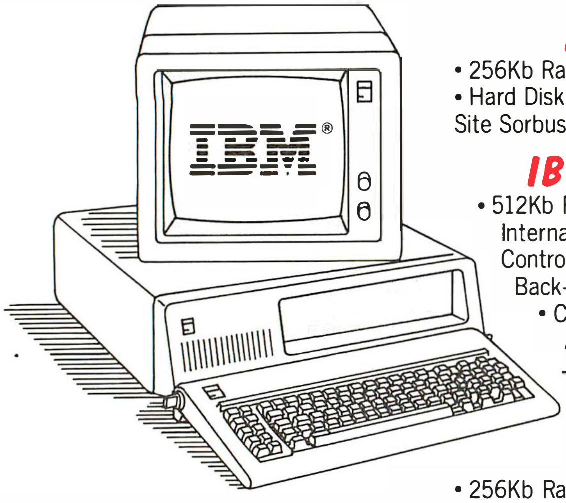
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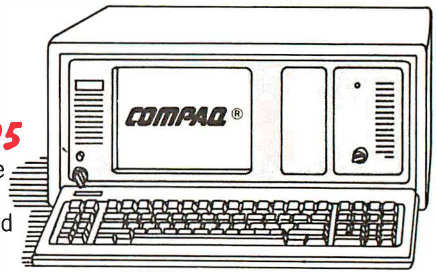
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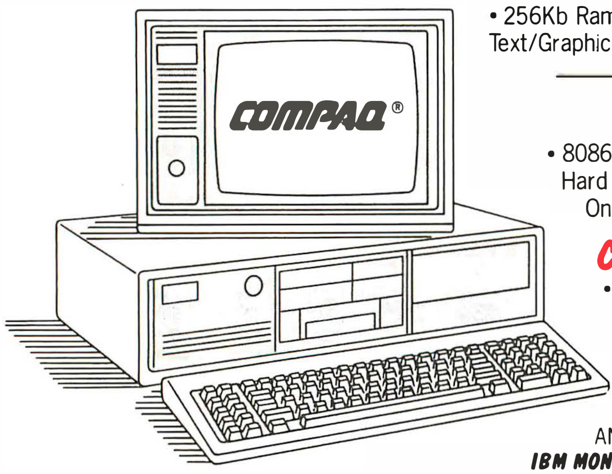
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BY LEONARD SHAPIRO

DATA DESIGN

The structure of data files is almost as important as their contents

You bought a database system. It was dBASE II, or pfs:File, or whatever. You loved it. You were able to write more reports faster, and you could access specific information much more readily. You thought of more things to do with your database, and you added more and more information to it. Other people wanted to use it. You thought of more applications. You added more files and more information to each file.

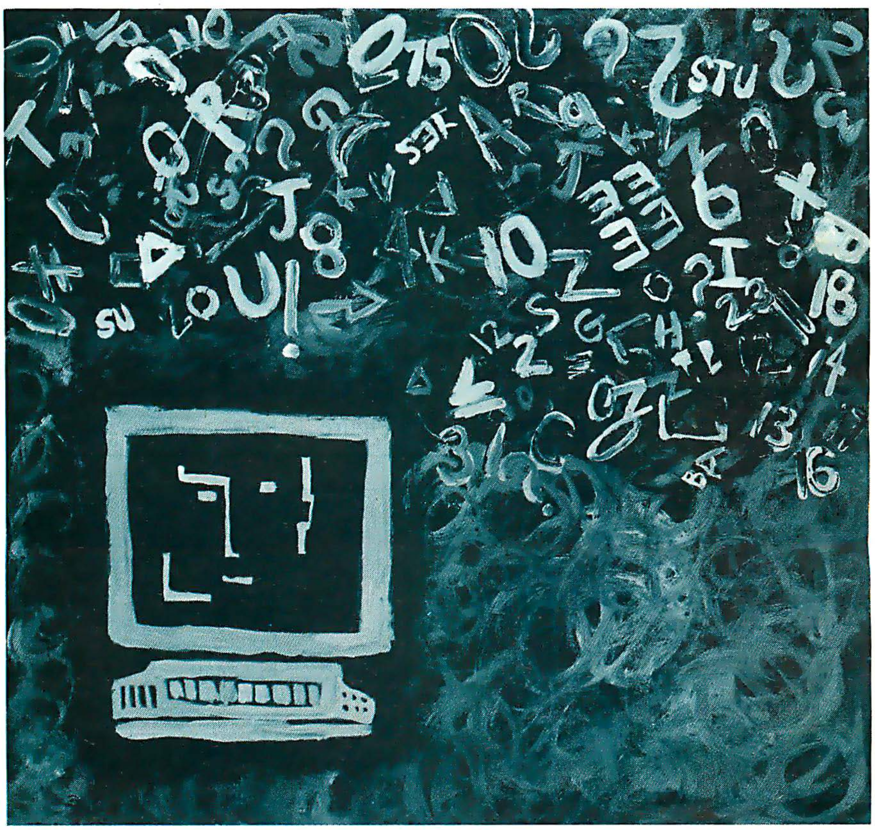
Now you are beginning to lose track of just what is in your database files. The same information seems to be in several different places. When you change one program or database file, other programs or files are affected. When you want to add a new application, it's not clear what files should be enlarged or whether a new file should be built. Your data needs some structure. You should apply principles of *data design* to your database, just as you should apply principles of structured programming to your programs.

Before structured programming techniques, all of us who wrote large programs complained incessantly about long, unwieldy programs. The principles of structured programming told us to build small program modules, using a few small constructs (WHILE, IF, etc.), and promised us that our programs would be vastly more understandable. It worked. Structured programs were easier to debug and to maintain. In fact, structured programming principles became so widely accepted that "languages" such as dBASE II include a few of them implicitly by omitting GOTO statements and including structured programming constructs.

Data design is a set of principles and analytic tools that brings to the design of your data the same kind of organization that structured programming brings to your programs. Data design is relatively unknown in the microcomputer community but has been known by other names to the mainframe community for years. Dif-

(continued)

Dr. Leonard Shapiro is a professor of computer science at North Dakota State University (*Fargo,* ND 58105).



ferent aspects of data design are called database design theory, normalization, or data modeling.

In this article I will discuss three important principles of data design: (1) your data is as important as your programs, (2) the structure of your data files is almost as important as their contents, and (3) some file designs are dangerous.

Bad Data and Bad Structures

You are the software guru in your business. Everyone comes to you for help. You have designed a database file called Help containing information about software contacts (see figure 1). Each record in Help contains three fields: the name of the software product, the name of someone to contact for help with that product, and a phone number where that person can be reached.

You have written a program called Findhelp to extract this information from the Help database. With Findhelp, you enter the name of a software product, and Findhelp displays the name of one person who can provide assistance and the number to call. You make the program available, and many people use it, especially for help with Procword, a popular word-processing program in your firm. Your program refers people to Elayne for help with Procword, but she is sometimes busy. Joseph discovers that Dan is always accessible, although he is not as helpful as Elayne. He adds Dan's name to the Help database (see figure 2).

Now you have a problem. You wrote the Findhelp program assuming that just one contact was available for each piece of software in the Help file. Now the program is giving only Dan's name when someone wants information about Procword. Elayne, the most helpful contact, is never called.

This example illustrates the first two principles of data design. By adding Dan's name to the Help file, Joseph made the Findhelp program much less useful, almost as if he had introduced a bug in the Findhelp program itself. Thus, poor data can do as much damage as poor programs.

The second principle has to do with the importance of the structure of your data files. Notice that the damage in this example was done even though Joseph did not delete

(continued)

HELP

Product	Contact	Phone
Spread	Carla	568-6588
Procword	Elayne	237-8194
Comm	Steven	485-0898
Procmail	Elayne	237-8194
Procbase	Elayne	237-8194

Figure 1: *Help, a database file of software contacts.*

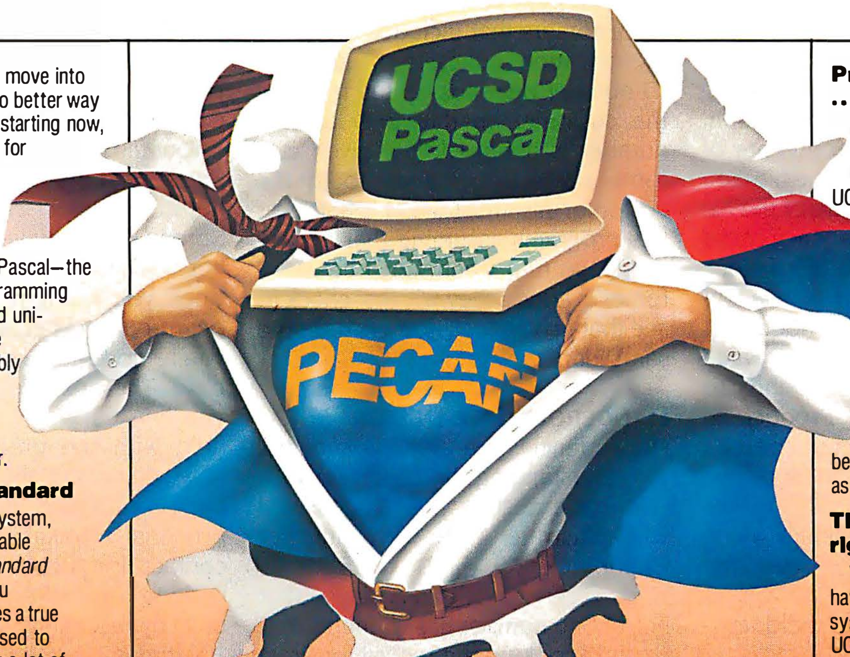
HELP

Product	Contact	Phone
Procword	Dan	263-2900
Spread	Carla	568-6588
Procword	Elayne	237-8194
Comm	Steven	485-0898
Procmail	Elayne	237-8194
Procbase	Elayne	237-8194

Figure 2: *Help, with a new contact, Dan, added.*

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B

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anything from the file. Joseph violated a *dependency*, namely, that only one contact per software product could be listed. You assumed this dependency when you wrote the Findhelp program, but when you explained the structure of the Help file to Joseph, you explained only the contents of each of the three fields in the file. You did not explain the structure of the file itself, including the dependency of the Contact field on the Product field.

The notation "Product => Contact" refers to such a dependency. It means that one and only one value in the field Contact corresponds to each value in the field Product. In figure 2, the dependency Product => Contact does not hold, since two Contact values, Dan and Elayne, are associated with the Product value Procword. Another way to describe the dependency Product => Contact is to say that the Product field *determines* the Contact field.

Dependencies like Product => Contact are perhaps the most important kind of structure that exists in databases. For example, in a database of customers that includes customer identification numbers, usually the ID number depends on the name of the customer, in that only one ID number is assigned to a given customer name. Those who modify the customer file must know whether it has programs assuming that dependency, so that whenever a new customer is added they will first check to see that no other customers have the same name.

Dangerous File Design

Dependencies are also fundamental to understanding the third principle, that some designs are dangerous. I will illustrate this with another example.

You receive a call from Elayne that her phone number has changed. You dutifully look up the record for Procword and make the change. But you forgot that she is also your contact for help with the programs Procmail and Procbase. Your database now looks like figure 3. Someone using your database to contact Elayne has a 67 percent chance of getting her old, incorrect number.

Your file design has other problems. Suppose Carla is a tremendously helpful contact for the product Spread, and you've managed to get her personal phone number. One week you find out that Spread has been recalled because it is faulty, so you remove its record from the database. The next week someone tells you that Carla is also a tremendous help with the product Comm, but now, unfortunately, you've lost her personal phone number. One last potential problem: If Elayne is your contact for 100 products, you are wasting a lot of space in your database by recording her phone number 100 times.

Of course, all this difficulty could have been avoided if you had foreseen that your database would be used as a phone directory. You could have made it in two pieces: one for the contacts and one for the phone directory.

Data design includes analytic tools that will help you create appropriate file structures without the need for foresight. These tools will prevent the problems described above, even when the files are large and complex, with many interrelated fields.

To avoid dangerous file designs you must have a clear understanding of the dependencies in your file. I will demonstrate the connection between dependencies and dangerous file structures by showing that the dependencies in Help give off clear warning signals to anyone familiar with data design.

Suppose that figure 4 lists all the dependencies in your Help file. Notice the *transitive dependency* from Product to Contact to Phone. A transitive dependency occurs when the fields A, B, and C have two dependencies, A => B and B => C (in figure 2 these dependencies are Product => Contact

(continued)

HELP

Product	Contact	Phone
Procword	Dan	263-2900
Spread	Carla	568-6588
Procword	Elayne	548-5206
Comm	Steven	485-0898
Procmail	Elayne	237-8194
Procbase	Elayne	237-8194

Figure 3: *Help, with inconsistent phone numbers for a contact, Elayne.*

Dependency
Product => Contact

Meaning
There is only one contact in the database for each product. (This dependency does not hold in the example of figure 2, because more than one contact is shown for the product Procword.)

Dependency
Contact => Phone

Meaning
Given a contact in the database, only one phone number in the database is associated with that contact. (This dependency holds in the example of figure 1, but not in figure 3.)

Figure 4: *Possible dependencies in Help.*

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and Contact => Phone) and no dependency B => A.

Any transitive dependency indicates a dangerous file structure. Just as Elayne's phone number was repeated unnecessarily in the Help file, a transitive dependency A => B => C will always invite repetition of values of B paired with values of C for different values of A. This repetition in turn can lead to inconsistent information if you change your database, as with Elayne's phone number being listed incorrectly. It also can lead to wasted space, as is the case with Elayne's phone number being repeated 100 times.

Transitive dependencies are a frequent cause of structural problems in the design of files. If you watch out for them, you are more likely to avoid the kind of difficulties I have described above.

WHAT TO DO?

I hope this article motivates you to look over your database files and chart the dependencies in them, then to look for transitive dependencies. But don't get carried away. Just as structured programming allows the use of GOTO statements when appropriate, data design theory should be interpreted as only a set of warnings to the designer. As dangerous as I have claimed the Help file design to be, several reasons might justify leaving it alone. For example, the usual way to eliminate a transitive dependency in a file is to split the file into two new files. Your database system may not support access to two files at once, or it may do so only at a great cost in processing time. Therefore, if you do find a transitive or embedded dependency in your files, consider all the ramifications before changing the file structure.

At least two important questions remain: If you find a transitive or embedded dependency, how do you correct it? And how do you design databases from the start so that they don't contain such dependencies? The answers involve a deeper understanding of the "join" operation in database systems and of the structure of information as "entities" and "relationships." A study of the books listed below should provide you with the knowledge you'll need to answer these questions on your own. ■

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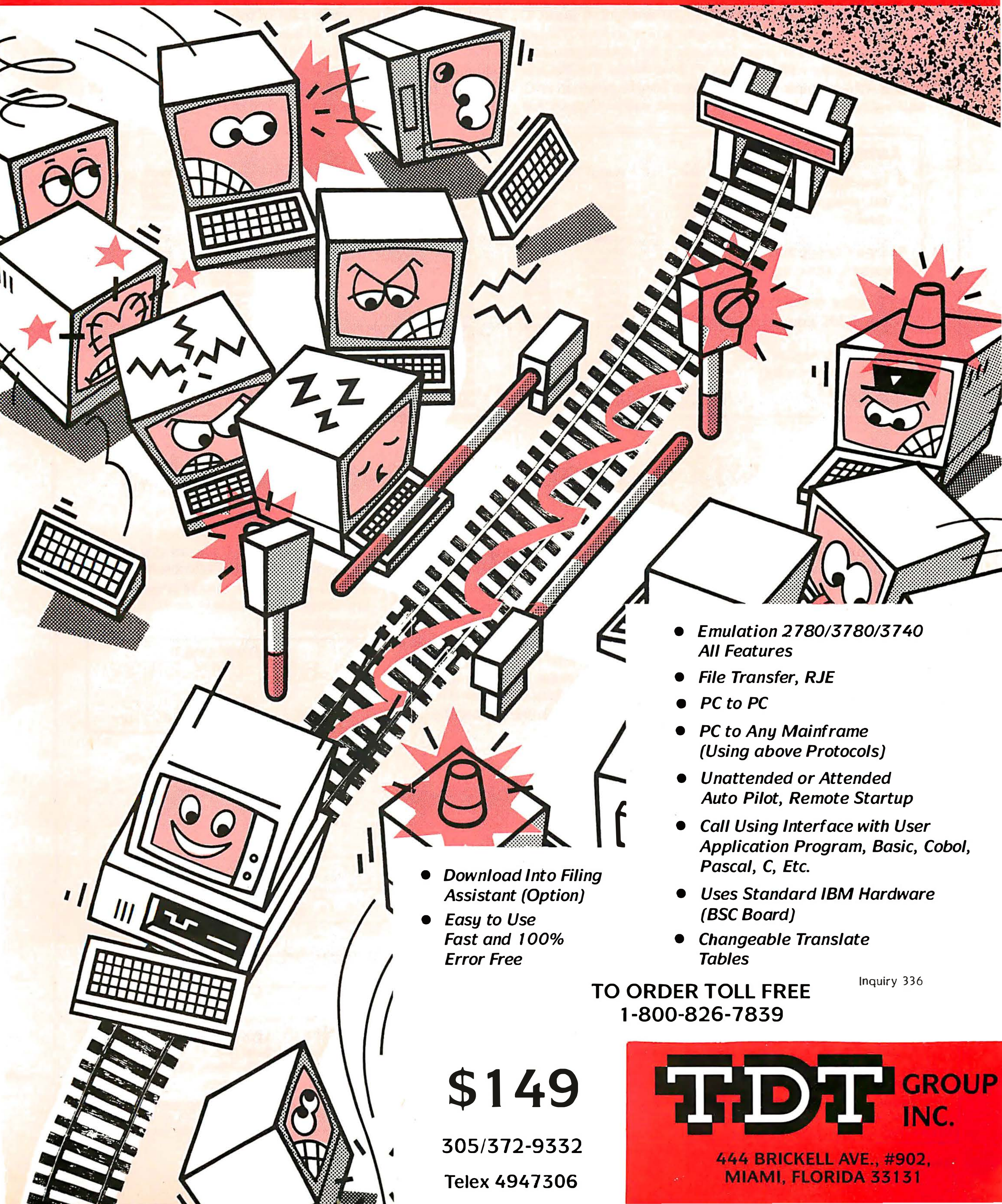
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DRAGON

BY BRUCE R. LAND

Recursive drawing of a dragon curve on the Macintosh

THIS PROGRAM uses the high-resolution Macintosh display and the rapid execution rate of MacFORTH (Creative Solutions Inc.) to produce a recursive drawing of the so-called Harter-Hightway Dragon (described in reference 1). The resulting curve (see figure 1) is interesting to look at because it has features on many different length scales, from the very smallest kinks to the major "body" segments.

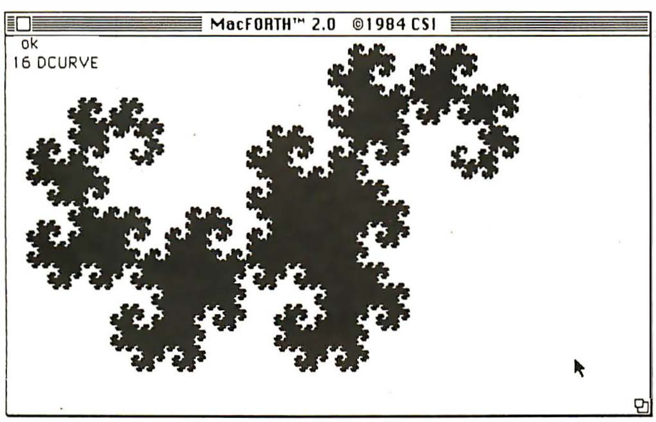


Figure 1: A *16th-order dragon drawn by the* FORTH *program* DRAGON.

The curve is constructed by successive fragmentation of line segments into ever-smaller right angles. This construction lends itself to implementation by recursion.

Recursion is a process by which a task is broken up into smaller tasks that are similar except for, perhaps, a count of how many times the smaller task has been performed. The unique feature of recursion is that a recursive procedure calls *itself* before it finishes execution, so that intermediate results pile up, to be resolved later when an end condition (for instance a count) indicates that the recursion is complete.

To perform recursion in FORTH you must consider two things. The first is that all local variables of the recursive routine must be on the stack, because when a routine calls itself, FORTH (unlike Pascal) does not make copies of variables for each invocation. The second is that FORTH normally assumes that no one would ever want to invoke a verb whose definition is not complete, so a recursive call within a definition is considered an error. This problem is easily handled by defining a verb called RECURS (reference 2) in listing 1 that temporarily tricks the compiler into considering the definition complete. As you can note in listing 1, this verb must always be used in pairs or strange things will happen.

FORTH is a bottom-up programming language in which you start with the primitive operations and build up complex ones. After defining the RECURS verb, the program defines four variables to locate a "drawing turtle." I used a turtle-graphic approach because the code was translated from Apple UCSD Pascal (reference 3). MacFORTH does not have turtle operations, but it is easy to produce the turtle operations TURN and MOVE. TURN accepts an angle (in degrees) on the stack and updates the turtle direction. MOVE causes the turtle to take one step forward in the direction it is facing.

The main work is done by DRAGON, which is the recursively called routine. Each time you enter DRAGON it calls itself twice until a value on the stack, called "level" in

(continued)

Bruce R. Land, Ph.D. (Box 73, RD #1, Trumansburg, NY 14886), is a senior lecturer at Cornell University.

Listing 1: *The* FORTH *blocks for the* DRAGON *program.*

```
Screen #1
( begin  Dragon curve )
CREATE CURVE    ( a FORGETable name)

CARTESIAN OFF

: RECURS  SMUDGE ; IMMEDIATE  ( trick verb for recursion)

VARIABLE ANGLE
VARIABLE XCOOD
VARIABLE YCOOD
VARIABLE STEPSIZE

: TURN (  deltangle-- | turn sign*delta)
  ANGLE +! ;

2 4 THRU


Screen #2
: MOVE ( -- | takes a step in present turtle direction)
  STEPSIZE @  DUP
  ANGLE @  COS *  10000 /  ( r* cos  of theta)  XCOOD @  +
  DUP ( newX)  XCOOD ! ( update X)
  SWAP
  ANGLE @  SIN *  10000 /   ( r* sine theta )   YCOOD @  +
  DUP ( newY)  YCOOD ! ( update Y)
  DRAW.TO    ;


Screen #3
: DRAGON ( sign level-- |  )
  DUP ( level) 0=
  IF   ( at bottom of recursion)
    DROP ( level)  DROP ( sign)   MOVE ( by stepsize)
  ELSE
    OVER  45 * TURN  ( getsign and turn)
    1 ( newsign)
    OVER   1-         ( level=level-1)
    RECURS DRAGON  RECURS

    OVER  -90 * TURN ( getsign & turn)
    -1 ( newsign)  ( edit to +1 for diff curve)
    OVER  1-             ( level=level-1)
    RECURS DRAGON RECURS
    DROP ( input level)  45 * TURN  ( getsign and turn)
  THEN   ;


Screen #4
: DCURVE ( level  --|  )
  ( init pen position)
  PAGE   100 XCOOD !    90 YCOOD !   360 6 *  ANGLE !
  WHITE PENPAT  XCOOD @  YCOOD @  MOVE.TO

  PEN.NORMAL
  1 STEPSIZE !
  1 SWAP ( level) DRAGON

  WHITE PENPAT   4 10 MOVE.TO    PEN.NORMAL ;
```

With this MacFORTH program, you can draw a 16th-order dragon curve in 4½ minutes.

the commands, reaches zero. At that point a step is drawn. A 16th-level dragon curve (the biggest that will fit on the screen) results in 2^{16} separate calls to DRAGON.

The final routine DCURVE initializes the pen position, sets up the stack for DRAGON, invokes DRAGON, and finally moves the pen away from the end of the curve. The program will draw a 16th-order dragon curve in 4½ minutes.

The program has a few limitations. The MacFORTH sine and cosine routines carry only four-place accuracy, so the program runs correctly only for even orders. An odd order causes the turtle to wander off the screen.

To run DRAGON, type N DCURVE, where N is the order desired. At one place in the program listing you'll see a notation that editing will produce an interesting variant. In particular, note that a 16th-order curve will not fit on the screen unless the STEPSIZE constant is unity. ■

[Editor's note: The source code for DRAGON *is available for downloading from* BYTEnet *Listings. The number is* (617) 861-9764. *It is also available on disk. See page* 346 *for details. You will need* MacFORTH *to run the program.]*

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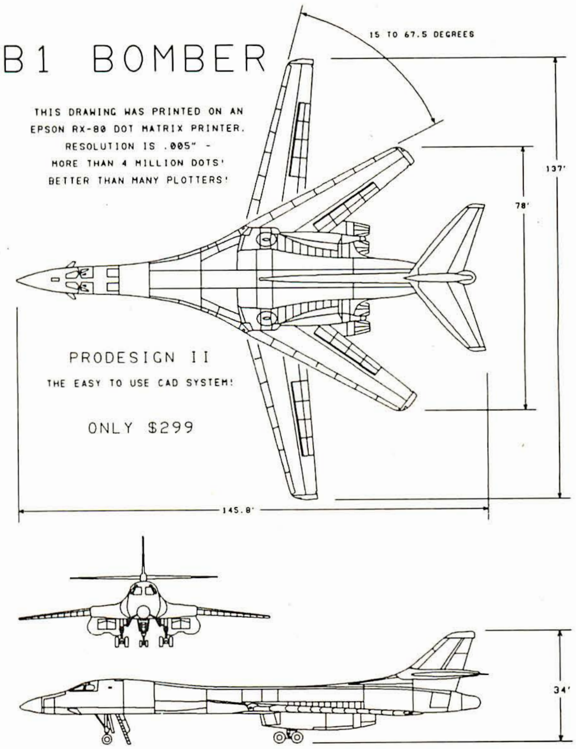
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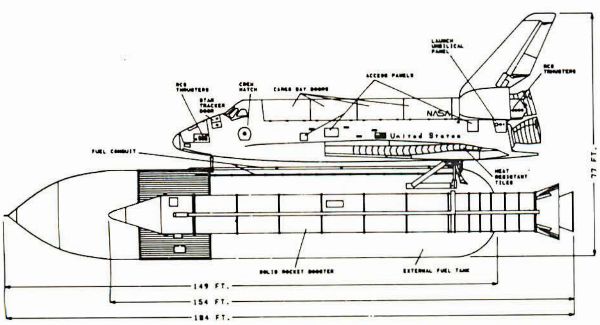
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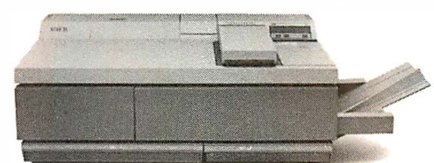


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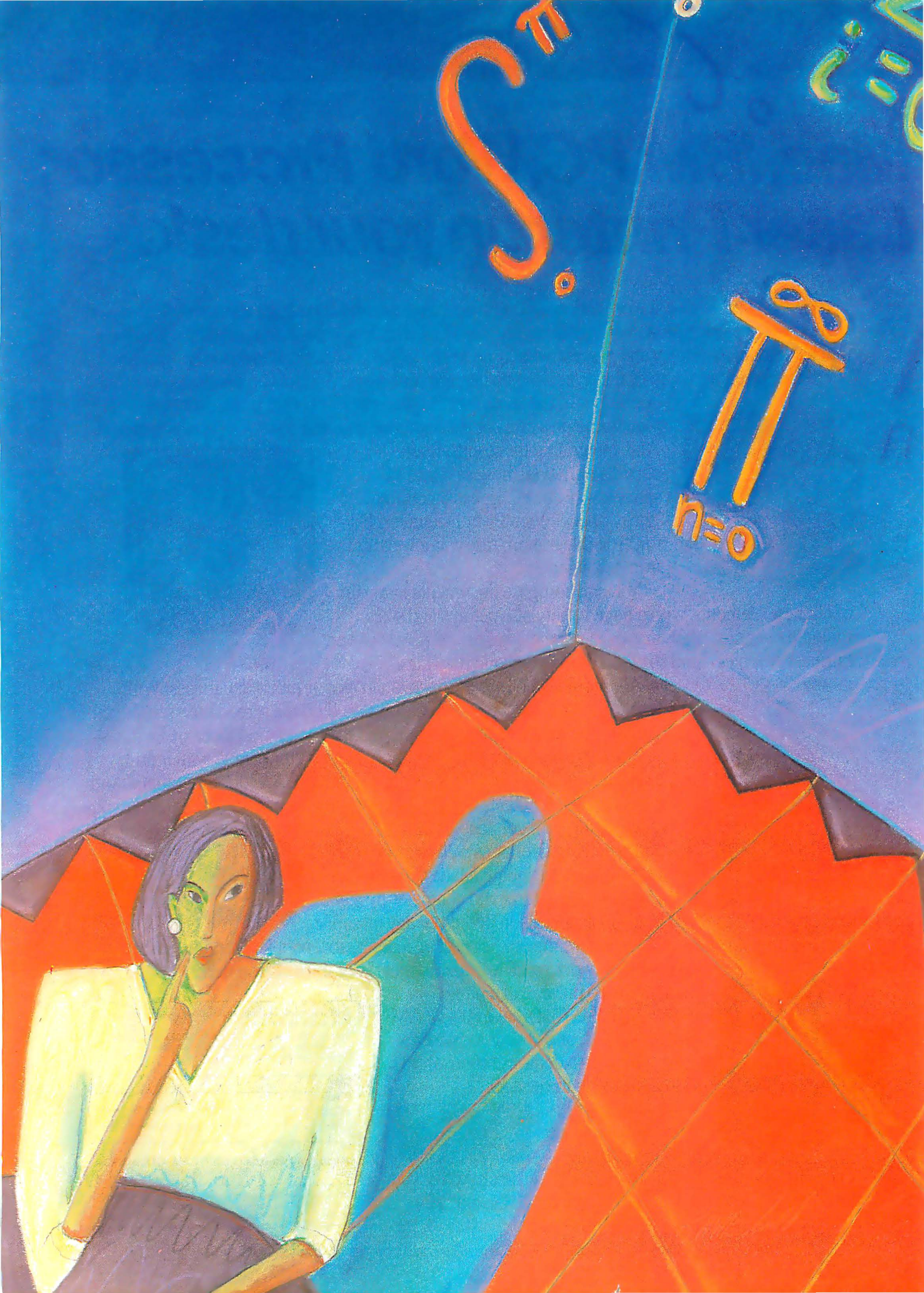
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n=0

Number Crunching

NUMBER CRUNCHING IS TO COMPUTING what speaking prose is to talking: We all do it and tend to take it for granted. So for this theme I wanted articles that rekindled the sense of amazement we all felt when we ran our first FORTRAN Fibonacci sequence program. Unlike that first program, however, these articles are important and useful. But more than that, they make number crunching seem new and exciting.

We start off with a remarkable hardware piece by Norman H. Christ and Anthony E. Terrano of Columbia University. They have made a parallel-processing micro monster that is twice as fast as a Cray-1! The muscles of this beast are 16 (so far) 80286/80287/TRW vector-processor nodes slung onto a Multibus skeleton.

The rest of the theme is devoted to software issues. We lead off the software discussion with Stephen L. Moshier's discourse on numerical precision and rates of convergence in computer approximations. Mr. Moshier structures his discussion around writing an exponential-function routine, but his insights are applicable to all numerical calculations.

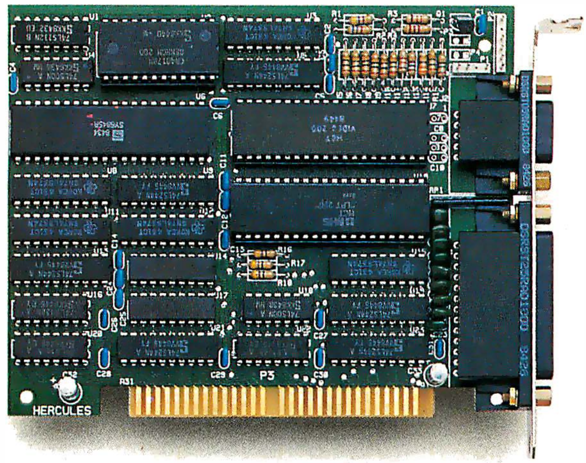
Many of us have written matrix-inverting routines. But how about routines to invert 50 by 50 or larger matrices? Thomas E. Phipps Jr. shows us the new Pan and Reif algorithm for inverting matrices as large as your computer can hold.

Next, Benku Thomas discusses the various flavors of Runge-Kutta algorithms for approximating solutions to systems of differential equations. Oddly, BYTE has never had an article on this classic technique. Among the many treasures in Mr. Thomas's piece is a FORTRAN routine for determining the machine epsilon (numerical resolution) of your computer. In the accompanying text box, David Leo presents a fourth-order Runge-Kutta routine in BASIC for solving spring-mass-damper systems.

Finally, Y. F. Chang presents one of the most awesome programs I have ever seen—a FORTRAN program that writes FORTRAN programs to solve systems of ordinary differential equations (ODEs) using Taylor series expansion through the first 30 terms. If you keep in mind that an *N*th-order RK *approximates* the first *N* terms of a Taylor series, and it is almost unheard of to do a Runge-Kutta larger than seventh order, you get some feel for what Mr. Chang is offering. The real virtue of his ODE solver is the ease with which this very-high-order solver dissolves stiffness.

I also want to direct your attention to a couple of related articles in other sections of the magazine. In the text box to his review of microTSP (page 257), Paul Davenport presents a brief introduction to time-series analysis. Time-series analysis is an alternative to Fourier analysis that is becoming increasingly popular in scientific as well as economic applications. And on page 57 I review an excellent new book on the fast Fourier transform.

—Tom Clune, Technical Editor



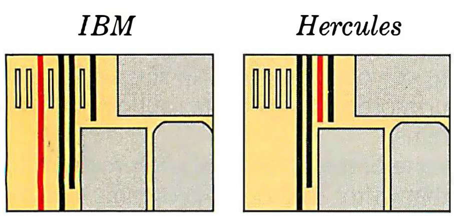
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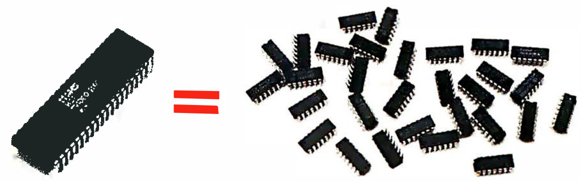


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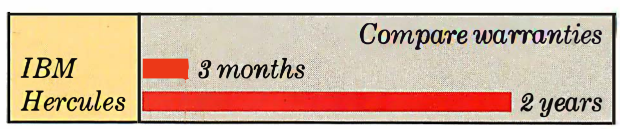
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A MICRO-BASED SUPERCOMPUTER

BY NORMAN H. CHRIST AND ANTHONY E. TERRANO

A unique combination of microcomputer parts yields supercomputer processing power

IN THIS ARTICLE we will describe a relatively simple parallel computer being built in the Physics Department at Columbia University. Although each node of the computer is quite similar to a microcomputer in complexity, the combination of many nodes is capable of speeds comparable to those obtained on today's fastest mainframe supercomputers. The device is pictured in photo 1.

Microprocessors are used in experimental university research for monitoring and controlling apparatus and performing data analysis. However, for the large-scale simulations common in theoretical science, the power of micros is simply inadequate. The arrival of Intel's 8087 (and now 80287) arithmetic coprocessors did not alter this situation. The speed of 100,000 floating-point operations per second, typical of an 8086/8087-based microcomputer, is still 1000 times slower than a Cray-1 supercomputer.

This state of affairs has been completely transformed by the manufacture of special arithmetic chips capable of up to 10 million floating-point operations per second (or 10 megaflops). It is now extremely attractive for theoretical scientists (especially those with limited university computing budgets) to harness these chips to microprocessors and, exploiting parallelism, build supercomputer-class machines. The project described here is an example of this approach.

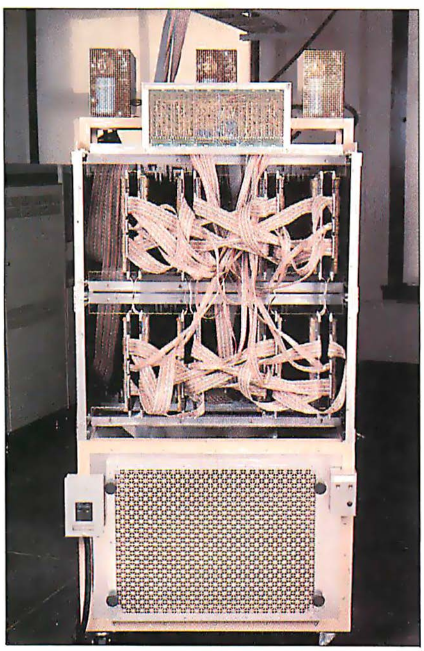


Photo 1: *Columbia University's parallel computer.*

These blindingly fast floating-point adders and multipliers are currently sold by Weitek, TRW, Advanced Micro Devices, and Analog Devices for prices in the range of $200 to $1000 each. Of course, these chips by themselves do not make up a complete arithmetic coprocessor. First, you need external storage registers to provide an interface to a standard 16-bit bus, and second, you must vary a number of input control signals to generate the desired sequence of arithmetic operations. About a dozen integrated circuits are needed in addition to the floating-point adder and multiplier chips for a working circuit. We refer to the resulting arithmetic unit as a "vector processor" because of its ability to execute a sequence of similar operations on a string (or vector) of data elements. Such a vector processor has the speed and programming characteristics of a com-

(continued)

Norman H. Christ holds B.A. and Ph.D. degrees in physics from Columbia University. Anthony E. Terrano holds a B.A. in mathematics from the University of Chicago and a Ph.D. in physics from Caltech. Both authors can be reached at the Department of Physics, Columbia University, New York, NY 10027.

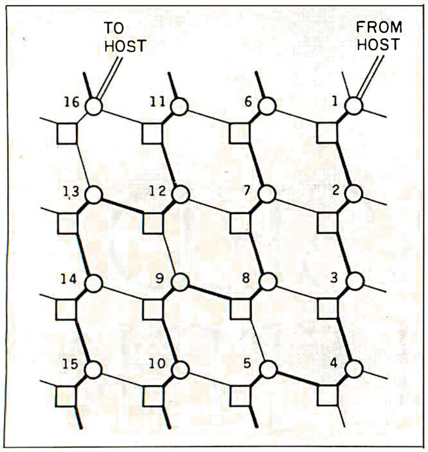


Figure 1: *The interconnection scheme for 16 nodes. The squares represent data memories, and the circles represent processors.*

mercial array processor.

This arithmetic unit is not as general-purpose as an 8087 or 80287 coprocessor. Since it is pipelined, full speed is obtained only when a sequence of similar operations can be executed consecutively. Also, the fastest of these chips work with 22-bit or 32-bit data (single precision), which is significantly less than the 80-bit data used internally in the 8087. However, for those applications that can tolerate these constraints, a single such unit can be added as a peripheral to a personal computer to boost performance as much as a hundredfold.

To achieve supercomputer speeds, however, one must join many of these units together. We interconnected these units in a two-dimensional mesh as shown in figure 1. The individual processors operate with full independence. They communicate by synchronously reading from or writing to their neighbor's memory. This sort of connection is very simple to implement in hardware and very fast. It is well suited to calculations performed on spatially homogeneous systems where at each stage the data (forces, particles, velocities, etc.) need only be passed between neighboring processors.

SINGLE-PROCESSOR ARCHITECTURE

The components of one of our computer's nodes are shown in figure 2. They are arranged on a single 12- by 18-inch board as shown in photo 2. The combination of the 80286/80287, the 32K bytes of RAM, and the 16K bytes of ROM joined to the Intel Multibus are typical of a high-end personal computer. The RAM (16 Inmos IMI400 static memories) and the ROM (two Intel 2764 EPROMS) are connected directly to the data lines on the 80286 to form a "local" data bus. They are enabled by standard address-decoding circuitry (three 74LS139 chips).

The bidirectional Y bus is the backbone (and bottleneck) for our system. Because it has ports connected to the four neighboring nodes, it can be used by the 80286 and the vector processor for off-board communication. In addition, it allows access to two banks of data memory. These banks, labeled A and B in figure 2, are each made of 32 static memory chips of 16K bits each. Again Inmos IM1400 parts are used, with 45-nanosecond access times. This memory appears to the 80286 as 128K bytes of additional fast RAM. However, it can also be addressed by the vector processor and each bank can supply a 16-bit word every 125 ns during a sequence of pipelined, vector-processor operations.

The final element appearing in figure 2 is the "X bus," which provides a second, unidirectional path from the

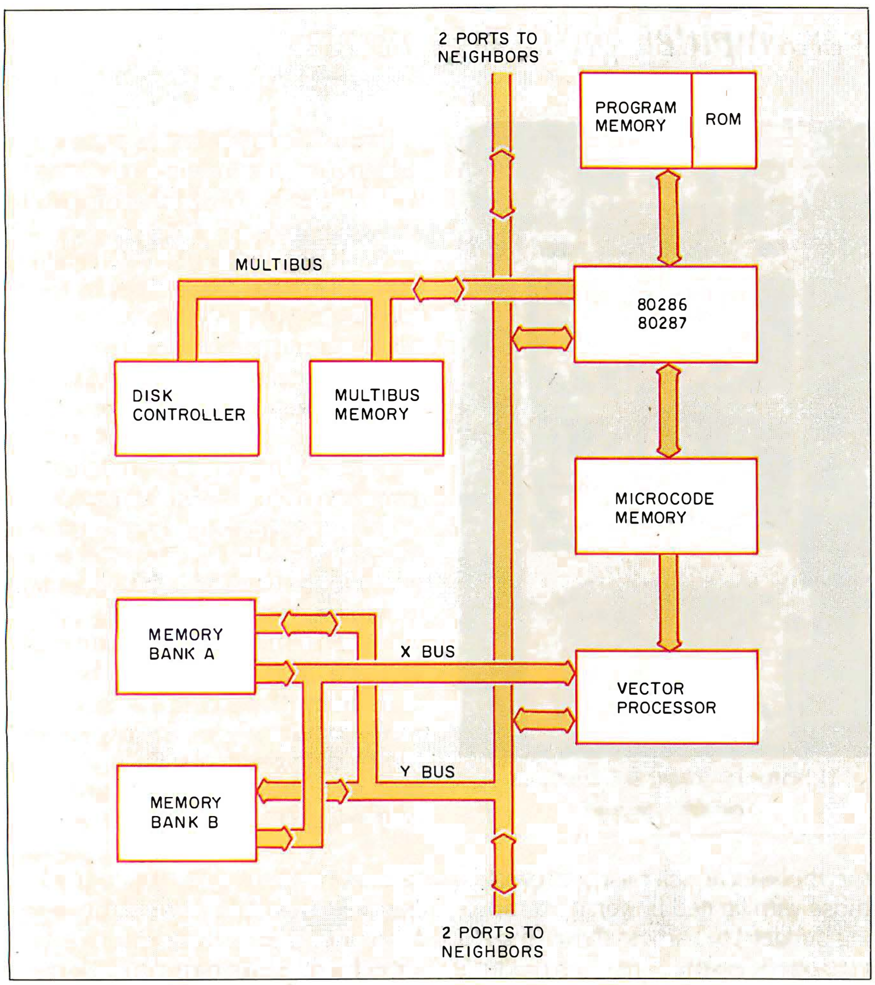
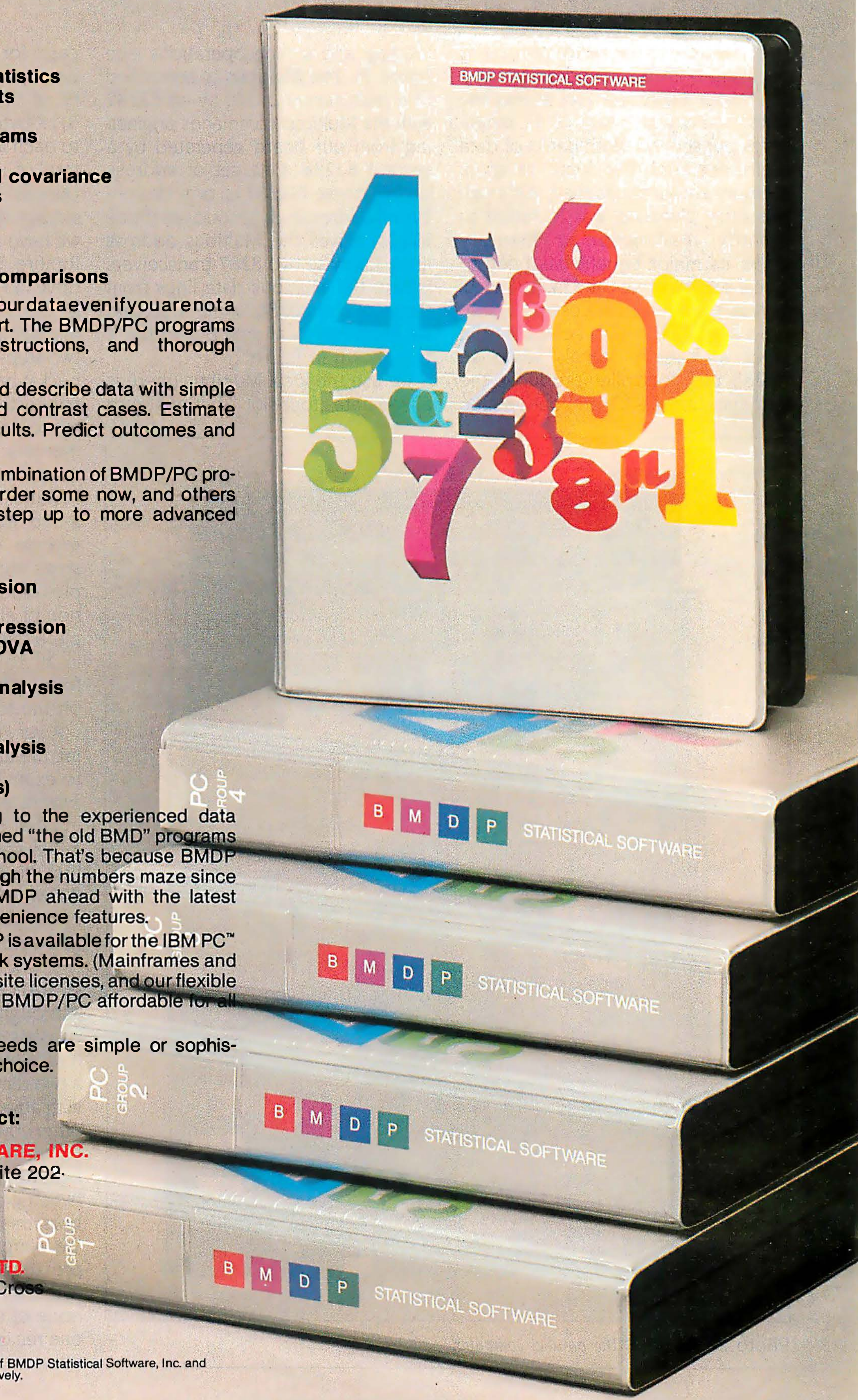


Figure 2: *The architecture of a single node of our machine. Only the major elements of the design are shown.*

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data memory to the vector processor. By using both buses independently, the vector processor can access the data memory at a rate of 32 megabytes per second. Both banks of data memories and the local program memory are parity-checked. Although this error checking was included to identify malfunctioning memory chips, its major benefit has been to reveal software bugs and faulty execution in the vector processor.

An Intel 82284 chip generates the clock and ready signals while an 82288 bus controller produces the command signals for on-board 80286 reading and writing operations (see figure 3). The Multibus is controlled in a multimaster mode by an 82289 with the Multibus commands originating from our board generated by a second 82288. One set of address latches (three 74LS373s) provides on-board addresses, a second set (three 8283s) drives the Multibus address lines. Likewise two 8287 transceivers isolate the Multibus data lines from those of the 80286, while a second set joins this local data bus to the Y bus shown in figure 2.

We use the local Multibus (there is a separate, four-slot Multibus card cage for each node) to provide for easy expansion of the storage capacity of the machine. At present, two 512K-byte memory boards are added to each Multibus card cage, adding a total of 16 megabytes of memory. As our calculations proceeded, this large storage space became inadequate, so we have attached a disk controller (a Rimfire 50) and 470-megabyte disk drive (a Fujitsu Eagle) to the Multibus of every fourth processor. The disk-managing software then operates in two steps: First the data is transferred, bucket-brigade style, to the processor connected to the disk where it is written to a reserved area in the Multibus memory; second, the controller is activated and copies the data from the Multibus memory to the disk. Reading a file from the disk works in the reverse order. Note that all these steps are usually carried out in multiples of four, with simultaneous operation of all four disk drives. For example, a data file made up of data stored in all 16 nodes will be divided into four parts and written simultaneously on the four disks.

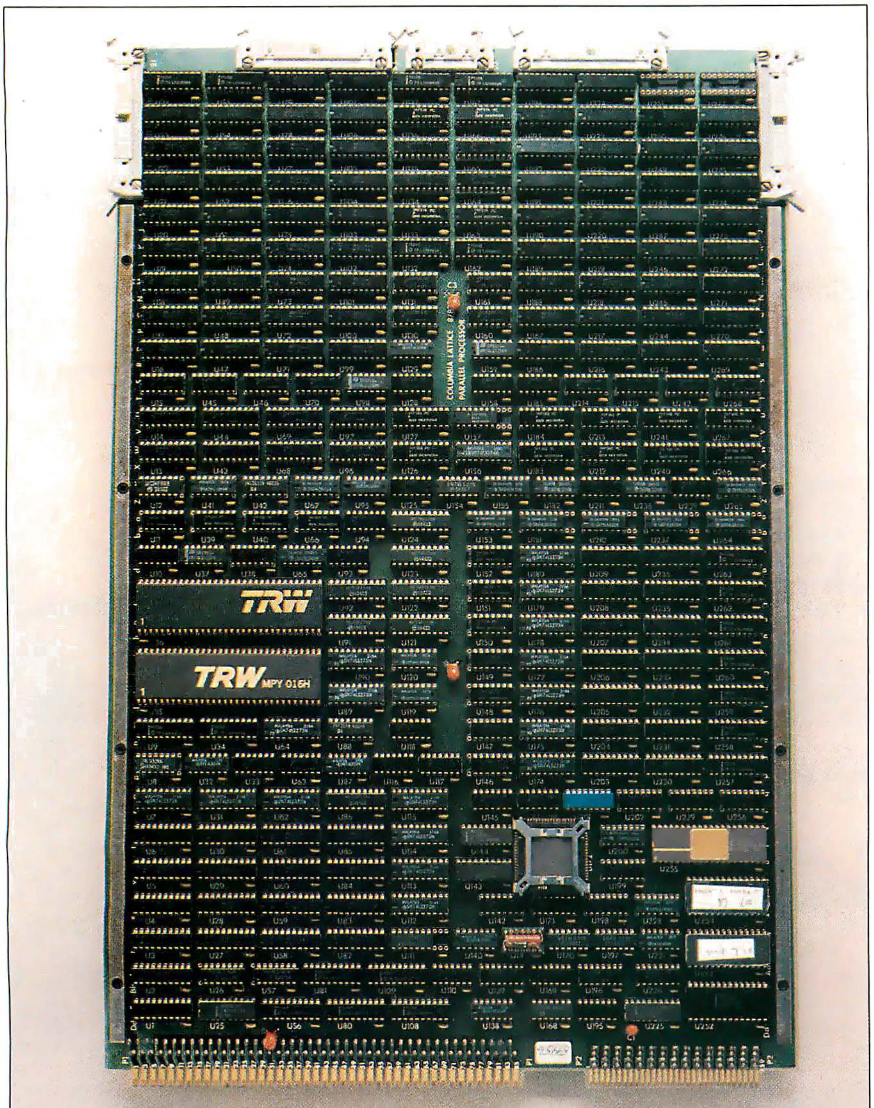


Photo 2: A *node of the parallel computer.*

A very concrete way of understanding the arrangement just described is to examine the memory map of the system as seen by the 80286 outlined in table 1. Only the Multibus and the initial startup address lie above the first megabyte of the 16-megabyte 80286 address space. Thus, the bulk of our programs operate in the fast, real-address mode.

PARALLEL ARCHITECTURE

Although each node in our machine consists of a processor and memory, it is useful to think of the system as a two-dimensional array of memories, with adjacent nodes joined to one another by the processing elements (figure 1). For a two-dimensional problem with physical interactions only between points that are nearest neighbors, this architecture is clearly ideal: We simply divide the plane of the problem into 16 identical regions, with each region corresponding to a node of the machine. Calculations in one region only require data from the adjacent regions. In each case there

is a unique processor with access to the two regions. Typically, that processor performs the calculation directly, with no data-copying operations.

For similarly local higher-dimensional problems, an identical strategy can be used. For example, a three-dimensional system with points labeled by three coordinates x,y,z would be divided into regions using only the two-dimensional x and y coordinates. Points with a given value of x and y but any value of z are assigned to the same memory.

Of course, the edges of the mesh should not be left unconnected. We separately join together the top and bottom and the right and left of the mesh shown in figure 1 to form a torus. This connection of the edges allows simple implementation of "periodic" boundary conditions. In order to avoid the long wires that would be necessary to join these distant edges, we actually fold the arrangement in figure 1 twice, first laying the left half over the right half so the left and right edges are adjacent, and then folding the top half over the bottom. The processors are physically arranged in a two-dimensional plane with the boards corresponding to the above folds interleaved. This procedure can be followed for an arbitrarily large mesh without increasing the length of the interconnecting cables (18 inches, in our case).

Superimposed on this two-dimensional mesh architecture is a "radial" connection of each processor to a very simple central controller as shown in figure 4. This controller provides a small amount of global coordination between the processors and all of the communication between the machine and the outside world. It is built on a single 7- by 14-inch wire-wrap board and is connected to each processor with a ribbon cable carrying eight signals. These include common clock, reset, and interrupt signals that are broadcast to each node. In the other direction, the controller receives "finished," "error," and "request for synchronization" signals from each board.

In addition to these identical connections to each processor, the controller is joined by 16-bit data lines to the Multibus of the first and last processors (the double lines to processors 1 and 16 in figures 1 and 4). The controller contains an 8K-byte buffer memory that can be accessed by the host computer. In an I/O operation, processor 1 reads a packet from this buffer memory. The data is passed daisy-chain style between the processors along a path specified in ROM (the heavy lines in figure 1), and finally processor 16 writes the packet back to the buffer memory.

We run the machine as a peripheral attached to a host VAX-11/780 computer, with a 1-megabyte data-transfer link to the controller. The host computer provides a convenient, multiuser environment to develop and run the programs for our machine. However, any means of providing support for the terminals, editors, and compilers, as well as a tape drive for data storage (such as a microcomputer or a slightly enhanced version of one of our boards) would suffice.

With the interconnection scheme shown in figure 1, each processor has

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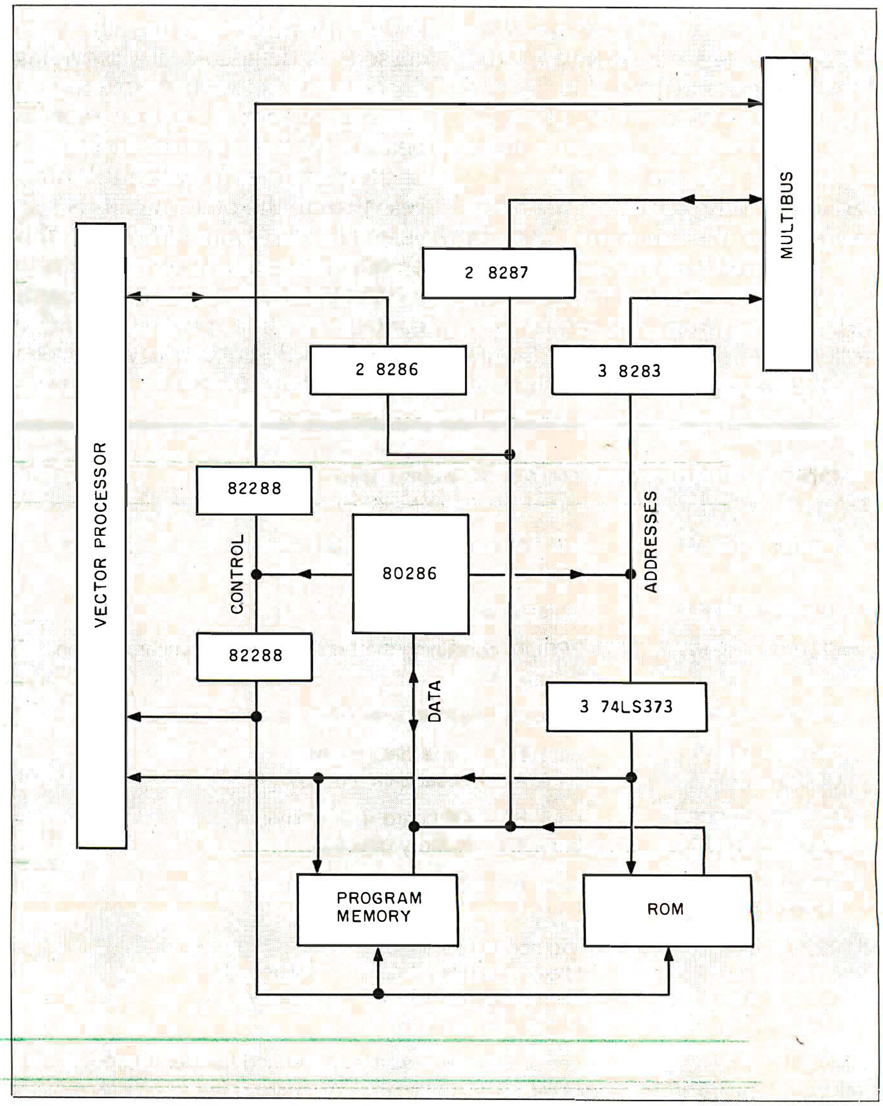


Figure 3: *The configuration of the 80286, its program memory, and the Multibus interface.*

access to the memory at three different nodes. This is accomplished by simply including all three of these memories in the processor's address space (see table 1). Each processor has unrestricted access to a single, contiguous 384K-byte memory. This implies that there are three different processors that have equal rights to read and write data to a given memory element. Clearly, some provision has to be made to restrict simultaneous references to a given memory element by two or more processors. The mechanism that we use to avoid contention rests on the simple observation that contention cannot occur if all of the processors are executing the same program in lockstep. Thus, if the processor at node 8 in figure 1 is using data in node 9, then the processor at node 9 will be using memory at node 14, and so on.

Such synchronization can be achieved at the hardware level by driving all the 82284 clock generators with the same external frequency (12 MHz) coming from the central controller. Likewise, a common 8-MHz signal provides the clock for the vector-processor sequencer discussed below. Synchronization of the processors is accomplished by releasing the reset line in phase with the oscillator. All of the clock generators will start on the same rising edge in the oscillator signal, and all of the microprocessors will start in phase. They will remain precisely synchronized for as long as they execute the same instructions on the same data.

The requirement that the processors be executing identical programs is obviously too restrictive. In order to see how we can relax this constraint, it is useful to change our perspective on the global architecture. Rather than considering the processors as democratically providing connections between the memories, we envision each of the processors as being more tightly connected to one of the memories to which it has access than to the other two, as is suggested by the layout of figure 1. This preferential coupling corresponds to the fact that each of our circuit boards contains both a processor and a memory, as described above. We refer to this preferred memory as the *local* memory and to the remote memories as the *x* or *y* memories, depending on their direction from the local memory.

From this perspective, we see that only the parts of the program that require nonlocal-memory references must be identical and synchronous. Those parts of the calculation that involve only local-memory references can be asynchronous. In fact, since each processor has its own code memory, these local, asynchronous parts of the program can be completely different on different processors. The programmer must separate each program into a number of nonlocal, identical, and synchronous subroutines, and a number of local, possibly inhomogeneous and asynchronous subroutines. Prior to executing a synchronous subroutine, each processor copies the starting address of the subroutine into a location that is read by the bootstrap program and raises its "request for synchronization" line to the controller. When all of the processors have requested synchronization, the controller issues the synchronous reset signal described

(continued)

Table 1: *Arrangement of the 80286 address space.*

FC0000 – FFFFFF	EPROM containing the bootstrap and resynchronization programs.		
F40000 – FBFFFF	Multibus address.		
FC000 – FFFFF	EPROM containing the bootstrap and resynchronization programs.		
E0000 – FNFFF	Decoded address lines used for control signals.		
D0000 – DFFFF	bank B	Local data memory.	
C0000 – CFFFF	bank A	Local data memory.	
B0000 – BFFFF	bank B	Off-board data memory	
A0000 – AFFFF	bank A	in the y direction.	
90000 – 9FFFF	bank B	Off-board data memory	
80000 – 8FFFF	bank A	in the x direction.	
66000 – 66FFF	Microcode bits 30–37		
64000 – 65FFF	Microcode bits 20–2F		Microcode
62000 – 63FFF	Microcode bits 10–1F		memory.
60000 – 61FFF	Microcode bits 0–F		
24000 – 25FFF	Vector processor startup signal and transfer address.		
20000 – 23FFF	Decoded address lines used for control signals.		
0 – 7FFF	Microprocessor program memory.		

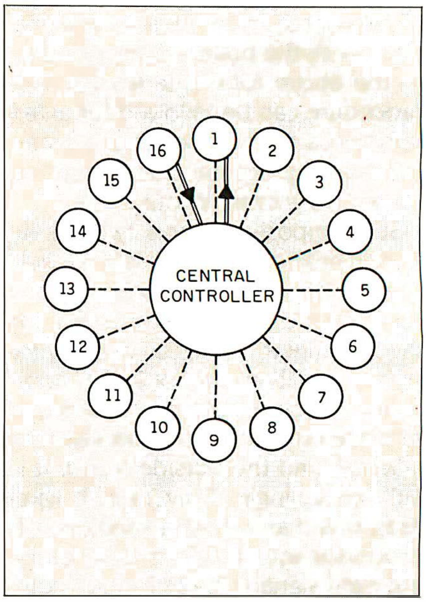


Figure 4: *The radial connection between the central controller and the parallel nodes. The doubled lines refer to the data paths between the controller and the first and last nodes of the I/O bucket brigade.*

MICROSOFT LANGUAGES NEWSLETTER Vol. 1-4

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```
DIM TRANSFORM3D(3,3) 'static array passed in COMMON
COMMON/GRAF3D/CURX, CURY, CURZ, TRANSFORM3D()
```

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above, and the processors begin executing the desired synchronous subroutine.

The principle virtue of this procedure for avoiding memory contention is its simplicity: No special hardware for detecting and arbitrating conflicting accesses is required. In addition, since the off-board memory references occur only when the processors are executing identical programs, the internode buses need carry only data. Rather than having to export addresses as well, each processor can address its own local memory, with the data being read or written by the appropriate neighboring processor. Furthermore, there is no communication overhead for nearest-neighbor off-board memory references; the data is simply accessible to the processor that needs it, and no explicit transfer operation is required. Some overhead is incurred if a remote processor needs the data. However, each interprocessor bus has a bandwidth of 16 megabytes per second, so transfer times can be kept small.

THE VECTOR PROCESSOR

The throughput of an arithmetic unit can be dramatically increased by the use of pipelining. A very high degree of parallelism can be achieved by breaking each operation into a number of stages of equal length and carrying out each stage in a separate processor. For example, a unit with 10 stages can work on as many as 10 operations at one time, calculating 10 answers in the time that an unpipelined processor takes to produce just one. We achieve the full speedup only if we can start an operation in every cycle. Our programs must be organized to keep the pipeline full as much as possible.

The vector processor is organized as a pipelined multiplier/accumulator, as is shown in figure 5. The floating-point adder is the TRW 1022, which performs a number of operations—add, subtract, accumulate, normalize, and denormalize—on 22-bit floating-point numbers. The integer multiplier is the TRW 16MPYHJ, which, combined with the exponent adder (two 74F382s), performs 22-bit floating-point multiplication.

The actual operation of this design can best be understood by viewing it as a pipeline with seven stages, each taking a single 125-ns clock cycle to complete. The first consists of clocking a significand into either or both of the two input latches of the integer multiplier. In the second stage, the exponents are clocked into the exponent adder latch, and the integer product of the significands from stage 1 is clocked out of the multiplier. During the third stage, the sum of the exponents of the factors and the significand of the product are clocked into an intermediate 22-bit latch, while overflow and underflow are detected. Since this stage follows the multiplication, it can be used to detect and correct the multiplication rule $-1 \times -1 = -1$ resulting from an overflow of fixed-point multiplication.

In the fourth stage, the correct floating-point product is clocked into one of the parallel 22-bit input latches in the adder. The adder itself contains a three-stage pipeline, and the fifth stage consists of the intermediate adder stage. The 22-bit sum is clocked

(continued)

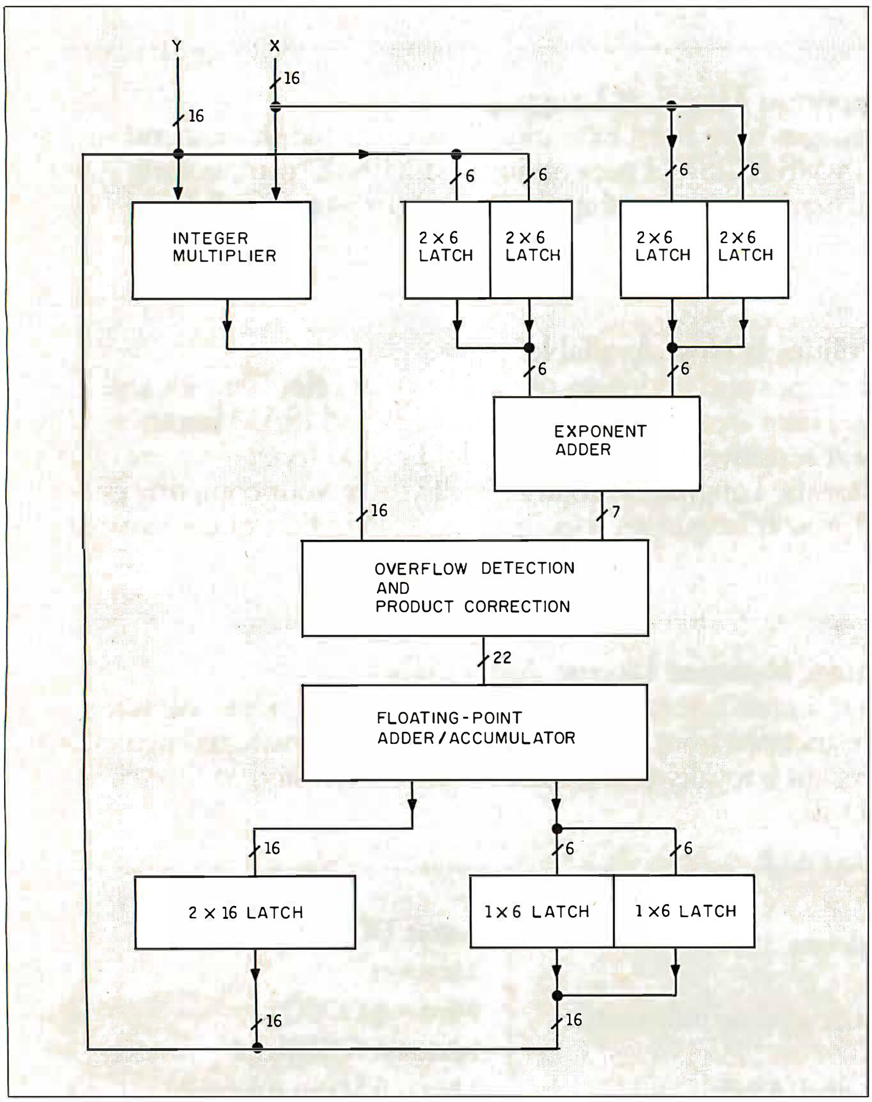
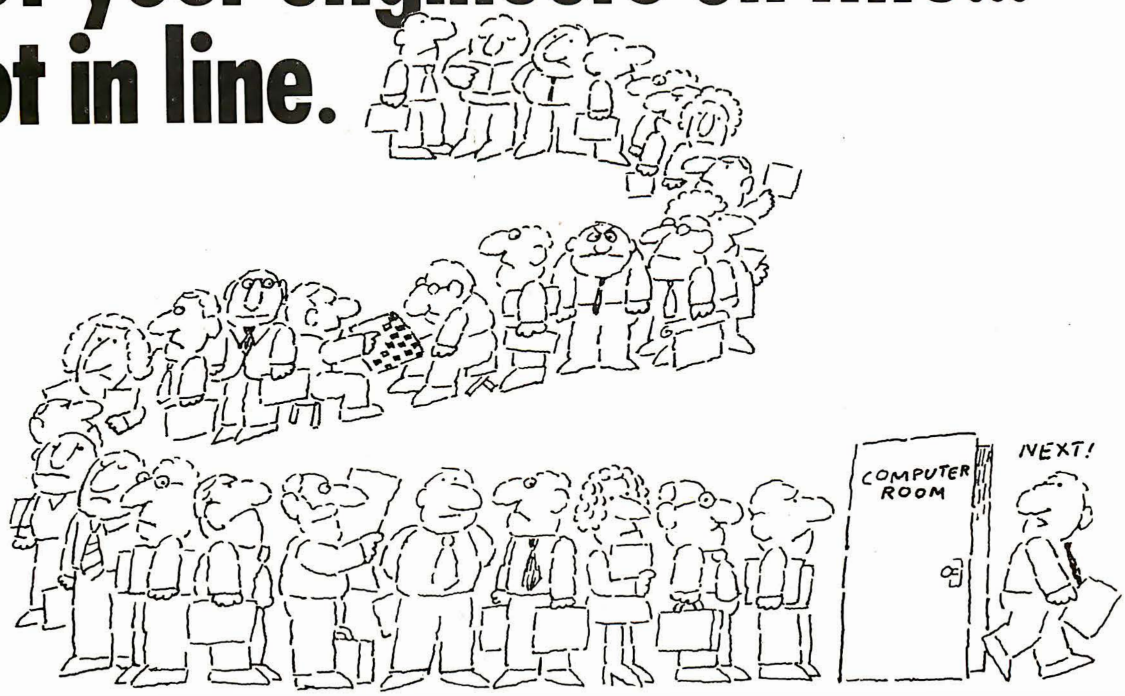
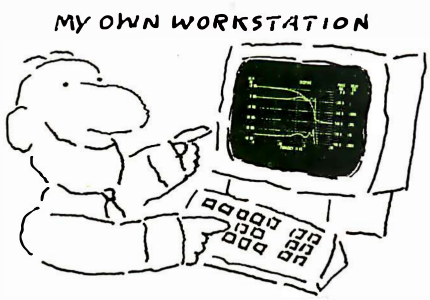
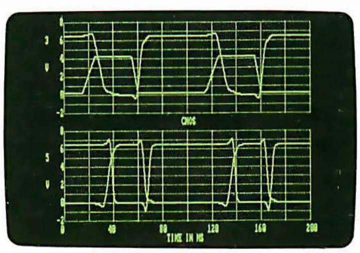


Figure 5: *The configuration of adder, multiplier, and latches making up a vector processor.*

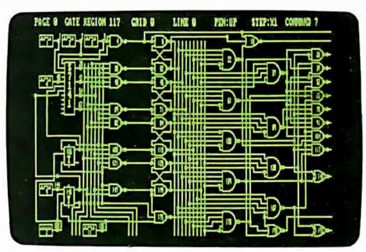
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The pipelined arithmetic unit requires the generation of a large number of properly timed control signals.

out of the adder in the sixth stage. In the seventh stage, the significand is clocked into one of two 16-bit latches and the exponent into half of another 16-bit latch. The outputs of each of the latches are connected together and joined to the bidirectional Y port. With this procedure, a full 6-byte complex number coming out of the adder can be packed into three 16-bit words and is ready to be stored in memory. Since the adder has two stages, it is possible to accumulate both the real and imaginary parts of a complex number at the same time.

Obviously, controlling such a pipelined arithmetic unit requires the generation of a large number of properly timed control signals. The most flexible way to supply these signals is through the use of microcode. In a microcoded processor, each of the control signals is provided by a single bit of a word stored in ordinary memory; the output of the memory chip is directly connected to the appropriate pin of the component that is to be controlled. A sequence of operations then corresponds to a particular sequence of bits stored in the control, or microcode, memory. The operations can then be performed by "reading" the appropriate sequence of microcode words. Our microcode memory consists of four thousand 56-bit words.

The program sequencer for this microcode memory is a simple counter under the control of the 80286. Vector-processor execution begins when the 80286 presets this counter to the beginning address of that portion of the microcode to be executed. The counter simply increments the microcode address at 8 MHz until a microcode stop bit becomes true. All of the decision making, looping, and branching are performed by the microprocessor. A single addressing mode is provided; an 8-bit offset stored in the microcode program is added to a 16-bit base address supplied by the 80286. This is done for both the A and B banks of the memory. The box enclosed by dotted lines in figure 6 shows the elements of the vector-processor controller.

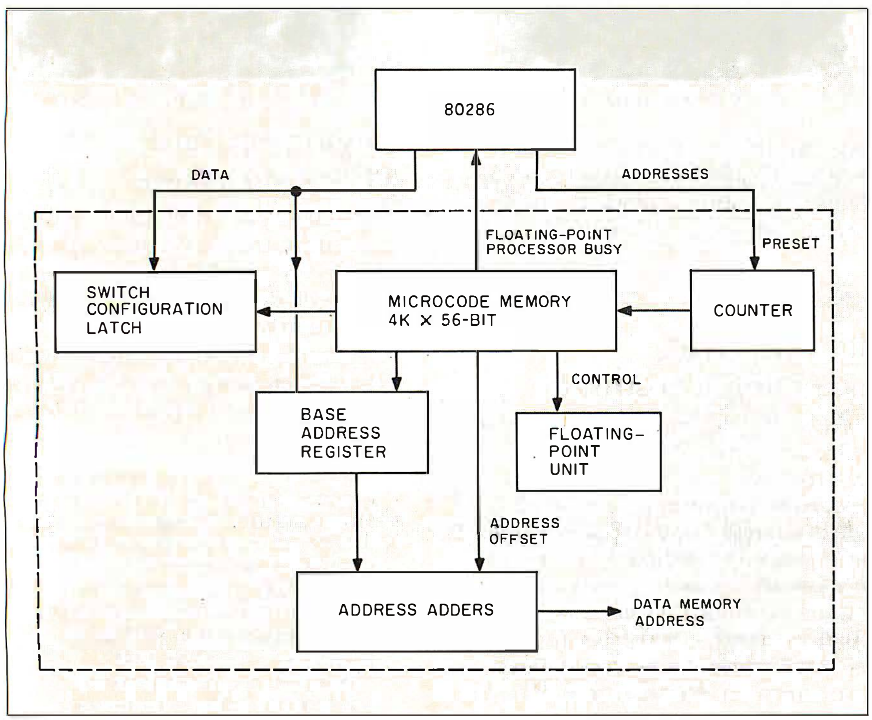


Figure 6: *The arrangement of the control system for the floating-point unit. That portion inside the dashed box makes up the elementary microcode control that can operate concurrently with the 80286.*

Before a vector-processor subroutine can be started, a memory-processor interconnection configuration must be specified. Either the local A or local B memory may be assigned to the X bus of the processor. If, for example, the A memory is chosen, then one of the B memories—local, *x*, or *y*—may be assigned to the Y bus. Different configurations can be specified for reading and writing operations. The specified configuration remains in force for the entire time the vector processor is running. The assignment is made by loading address bits 16 to 19 into the switch configuration latch. A complete 20-bit memory address is then determined by combining the 16 bits calculated above with the 4 bits in the switch configuration latch.

A typical compute-bound program consists of a large number of floating-point arithmetic operations that are carried out by the vector processor, combined with a small number of integer and Boolean operations, plus jumps and subroutine calls, performed by the microprocessor. To keep the vector-processor pipeline full, we organize our program so that most of the floating-point operations are grouped together into subroutines that can be performed without intervention by the 80286.

Each of these subroutines must be a linear series of multiply/accumulates, possibly arising from expanding the inner DO loops in a program for a conventional, unpipelined computer. These subroutines are converted into microcode programs that

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can be called as needed in the main program. Once loaded into the vector processor's program memory, these subroutines effectively become extensions of the 80286's instruction set in much the same way that the 80287 adds floating-point operations to the instructions available.

Rather than having to write the microcode cycle by cycle, explicitly specifying each concurrent pipelined operation, it is possible to design an assembler that can generate the microcode needed for this restricted class of subroutines. The input to the assembler consists of the specification of a series of arithmetic operations to be performed. In particular, since the vector processor is a hardwired multiplier/accumulator, each op code specifies a multiplication followed by an addition.

Having restricted the class of subroutines that will be microprogrammed, only a few sequences of operations to be performed on a pair of numbers can arise. This makes it possible to assign a single assembler instruction to the entire time sequence of operations. For a given op code, the assembler generates a template, specifying the sequence of address offsets, latch enables, strobes, and control instructions with the proper timing relations needed to perform the desired arithmetic operations. The problem of keeping the pipeline full is then reduced to that of fitting together the templates as closely as possible without actually overlapping. This can be done by hand, by specifying delays between the operations, or it can be done automatically by the assembler. Both the FORTRAN and assembler versions of a program to calculate the product of two 2 by 2 complex matrices are shown in listing 1.

The full functionality of the vector processor is available for operations on real numbers. Any of the floating-point-adder hardware instructions can be specified when the output of the multiplier is clocked into the adder. For complex numbers, the operations are restricted to loading the complex product of two numbers into the adder or adding the product to a number previously loaded into the adder. Either instruction can also specify that the result is to be stored in a memory location. In addition, the complex instructions can be specified to act on the complex conjugate of either or both operands.

Two data types, REAL*3 and COMPLEX*6, are provided for. The real format is determined by the design of the floating-point adder and consists of a 16-bit significand, including the sign bit, coupled with a 6-bit exponent. A REAL*3 number is stored in three consecutive bytes, with the significand in the first two bytes and the exponent in the third. The COMPLEX*6 format combines two real numbers packed into three words: the real significand is stored in the first word, the exponents in the second, and the imaginary significand in the third. The assembler can interpret both single variables and one-dimensional arrays, with all offset calculations being performed automatically.

Listing 1: *A program to multiply two 2 by 2 complex matrices. Versions written in* FORTRAN *and in microcode assembly language are shown.*

```
        subroutine mtm(m1, m2, ans)
        complex m1(2,2), m2(2,2), ans(2,2)
        ans(1,1) = m1(1,1)*m2(1,1)+m1(1,2)*m2(2,1)
        ans(1,2) = m1(1,1)*m2(1,2)+m1(1,2)*m2(2,2)
        ans(2,1) = m1(2,1)*m2(1,1)+m1(2,2)*m2(2,1)
        ans(2,2) = m1(2,1)*m2(1,2)+m1(2,2)*m2(2,2)
        return
        end

var m1  complex a 0     ;declare complex array
                        ;m1, in memory a
var m2  complex b 0     ;declare complex array
                        ;m2, in memory b
var ans complex a 0     ;declare complex array
                        ;ans, in memory a
xpi  m1 0  m2 0         ;initialize pipe and
                        ;multiply m1(0) by m2(0)
xpf  m1 1  m2 2         ;accumulate m1(1)*m2(2)
                        ;and flush pipe
xs   ans 0              ;store result in ans(0)
xpi  m1 0  m2 0
xpf  m1 1  m2 2
xs   ans 1
xpi  m1 0  m2 0
xpf  m1 1  m2 2
xs   ans 2
xpi  m1 0  m2 0
xpf  m1 1  m2 2
xs   ans 3
end
```

THE VECTOR-PROCESSOR INTERFACE

The interconnection between the microprocessor and the vector processor is shown outside the dotted box in figure 6. As was described above, control is passed from the microprocessor to the vector processor by presetting a counter and loading a number of latches. Since the entire microprocessor program is stored in an independent program memory, the 80286 can run concurrently with the vector processor. The interface between the two processing elements is designed to allow the 80286 to prepare to start the next microcode program before the one presently executing has finished and then start this next routine as quickly as possible.

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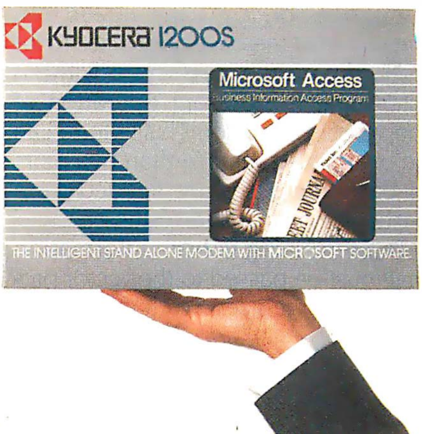
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Running the machine at maximum efficiency requires that the microcode programs be organized so that they contain at least 200 operations.

Calling a microcode subroutine from the master program is functionally identical to a FORTRAN subroutine call, with the arguments passed by reference. However, a special subroutine linkage is needed, since the microprocessor is handing off the control of the execution of the program. The addresses of the operands are written into the address latches, located at fixed memory locations rather than copied onto the stack. Similarly, transferring program control to the microcode subroutine requires writing the address of the initial instruction of the subroutine into the sequencer rather than saving and loading the program counter.

The base address registers used by the vector processor allow simultaneous reading and writing. These operations do not interfere with each other provided different registers are being accessed. We connect the least significant bit of the reading address to that of the writing address through an inverter and drive the writing address bit with a flip-flop whose state is toggled with each start of the vector processor. Thus the 80286 can directly load the base addresses to be used during the next cycle without disturbing the present operation of the vector processor. This feature can be overridden if more than two pairs of base addresses are needed for a particular microcode routine.

The remaining control information that must be passed to the vector processor is organized so that it can be transferred in the single write operation that starts the microcode execution. A microcode routine is initiated by writing to a reserved address range (table 1). The segment portion of that address is decoded to start the vector processor. The offset is directly preset into the microcode address counter, determining the address of the microcode routine to be started. The data being written during this operation determines the interconnection configuration to be used by the microcode routine and is clocked into the switch configuration latch shown in figure 6.

The time required to set up the vector-processor control registers depends on the number of arguments being passed. For example, the time required to start the program shown in listing 1 is approximately 12 microseconds. The vector processor can carry out nearly 200 operations in this amount of time. Thus, running the machine at maximum efficiency requires that the microcode programs be organized so that they each contain at least this many operations.

Provision must be made to delay the next start-up instruction until the current vector-processor program has completed. A continuous sequence of microprocessor wait states is generated if the 80286 writes to a reserved address (VWAIT) while the vector processor is busy. Thus, before starting the next microcode routine, the 80286 writes to VWAIT. This operation is extended indefinitely by wait states until the microcode execution has completed. When the current microcode program finishes, the 80286 is released from the wait state and executes its next instruction, normally the "write" described above that restarts the vector processor. With this technique, only 700 ns need typically elapse between the end of one vector-processor operation and the beginning of the next.

Achieving this speed requires that the order of the microprocessor's instructions be adjusted so that the instruction queue is filled prior to executing the write instruction to VWAIT. By prefetching the instruction that will restart the vector processor before entering the wait state, the microprocessor will be able to decode the instruction while the vector processor is still running. Typically, this requirement can be met by performing a register-to-register operation immediately before executing the wait instruction, freeing the bus for prefetch use. Listing 2 contains the 80286 assembly language that loads the required registers and initiates the multiplication of two matrices by the vector processor, using the microcode program in listing 1.

The microprocessor programs are generated using Intel cross-compilers (FORTRAN and PL/M) and an Intel assembler running on the VAX-11/780 host computer. The output from the microcode assembler is a standard, Intel format, relocatable object module. The microcode is stored in four initialized arrays corresponding to the four 16-bit words that make up an individual microcode instruction. Each of the arrays is assigned to a separate segment. The modules containing the microcode are then linked together using the Intel link editor, and the segments can be assigned the appropriate addresses in the microcode memory when the absolute load module is produced. In addition, the initial instruction is declared to be a public variable, making the starting address of the microcode subroutine conveniently available to the microprocessor programs. The microcode module can then be linked in the usual fashion with the program modules produced by the compiler for the microprocessor.

Conclusion

When we set out to build this machine we had two goals in mind. First, we hoped that by interconnecting a very large number of simple processors we would achieve number-crunching speeds well beyond those possible on commercially available supercomputers. Second, by coupling state-of-the-art VLSI floating-point chips with very fast microprocessors we believed we had a design sufficiently simple

(continued)



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that it could be built and programmed by a group of dedicated amateurs, thereby reducing construction and operating costs by at least a factor of 100. How have we done?

Let us first address the question of performance. Table 2 compares an IBM PC (with an 8087 installed), a VAX-11/780, and two Cray-1 computers with our machine. The first column refers to raw speed—the maximum number of floating-point operations per second (in megaflops) that can be executed. A more important comparison uses the speed for a real application program. In our case this is a Monte Carlo simulation of the laws of force obeyed by the "quarks" making up the neutrons and protons out of which the atomic nucleus is built. In this statistical simulation you sequentially update the variables associated with the links of a four-dimensional lattice in space-time. It is this link-update time that is listed in table 2.

As can be seen from table 2, we have not yet met our first goal. The Cray XMP-4 outperforms us by a factor of 4. However, that goal may not be far away. We are now more than halfway through the construction of a 64-node machine equal in power to the Cray XMP-4. This machine should be operational within the next few months. A 256-node version is under construction, and it should require less than a year and a half to complete.

With regard to economy, the situation is already very clear. We can fabricate one of our nodes for less than $3000. The cost of the 16-node machine—including the disk drives, controllers, and Multibus memory—is under $150,000, well below the multimillion dollar price tag for a comparable supercomputer. The savings in operating costs are even greater. The group of faculty and students who built the machine and wrote the operating system and application programs can quite easily maintain it. (So far we have averaged one failure every three months.) Thus the major operating expense is electricity.

The machine described in this article is inferior in many respects to a commercial supercomputer. The configuration of the floating-point hardware is much less versatile, the arithmetic is less precise, the highly parallel operation is seriously constraining, and the programming environment is far from user-friendly. Nevertheless, our efforts demonstrate that by focusing on a particular class of applications and forgoing some of the conveniences associated with a commercial product, you can build a flexible and very competitive supercomputer-class machine. ■

Listing 2: *The 80286 assembly-language program that initiates the execution of the program shown in listing 1.*

```
mtm:

 mov   si,[bx+2]      ;load the pointer to the
 mov   ax,lind[si]    ;first matrix into bal1,
 mov   bal1,ax        ;a base address latch for
                      ;B memory.
 mov   ax,[bx+4]      ;load the pointer to the
 mov   aal1,ax        ;second matrix into
                      ;aal1, a base address
                      ;latch for A memory.
 mov   ax,[bx+6]      ;load the pointer to the
 mov   aal3,ax        ;destination matrix into
                      ;aal3, a base address
                      ;latch for A memory.
 mov   ax,0d0c0h      ;load the intended
                      ;contents of the memory
                      ;control latch into ax.
 add   bx,8           ;set bx to point to the
                      ;next routine.
 mov   vwait,ax       ;wait until the vector
                      ;processor has finished
                      ;the previous operation.
 mov   svp+mumtm,ax   ;load the memory control
                      ;latch (at address svp)
                      ;and start the vector
                      ;processor. The lower
                      ;bits of the address
                      ;(mumtm) determine the
                      ;microcode program being
                      ;started.
 jmp   tab[bx]        ;jump to the next portion
                      ;of code selected by bx
                      ;which starts up the next
                      ;microcode program.
```

Table 2: *A comparison of both peak speed and execution time for the basic element of an application program.*

Computer	Peak Speed (megaflops)	Link-Update Time (microseconds)
IBM PC	0.1	200,000
VAX-11/780	1	20,000
Cray-1	160	80
Cray XMP-4	1000	15
16-node machine	256	65

ACKNOWLEDGMENT
The authors would like to thank the Department of Energy and Intel Corporation for their support.

COMPUTER APPROXIMATIONS

BY STEPHEN L. MOSHIER

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In the case of transcendental functions, such as $Y = \exp(2)$, not even we humans have a number for Y. We may remember from a math course that the exponential (or antilogarithm) function can be defined as the given summation of an infinite series of terms. (See figure 1, equation 1. All equations are in figure 1 and will be referenced by an equation number appearing in parentheses to the left of the equation.) We can get only an approximate value by adding up a finite number of the terms in this series. To obtain a fairly accurate result, we have to include a large number of terms. Moreover, each term must be calculated to a correspondingly large number of decimal places.

Before computers and desk calculators, the preparation of a numerical table for functions such as logarithms or exponentials was a major undertaking. Mathematicians therefore devoted considerable thought to calculation methods that are both fast and accurate. To mention just one example, the mathematician Gauss made use of a fast Fourier transform algorithm as long ago as the year 1803. A rich legacy of tricks for manual computation provides us today with many efficient algorithms for computer routines.

The objective of computer approximation is to calculate the value of a function to a given accuracy while expending as little computational energy as possible. Because of the various tricks that can be brought into play, this short article cannot present a cut-and-dried design technique. However, there is a small set of problems that have to be addressed in writing any numerical function routine. Each of these problems will be discussed here in relation to a specific programming example. The main connecting theme, or plot, will be to design a program to compute the exponential function. We shall see that this leads us into several interesting subplots.

ROUND-OFF ERROR

Let's review the way in which computers represent numbers. In order to handle a large range of numbers, from very small to very large, computers use a "floating-point" representation. This is exemplified by the so-called scientific notation for numbers, such as 0.987654E3, which means 987.654. Floating-point numbers contain a part called the "exponent," which in the above example is the 3, and a "mantissa," which in the above is 0.987654. The number of significant figures permitted in a computer number is usually fixed; this limits the precision of arithmetic operations. If, as in the example, a number can have six significant decimal figures, then its relative precision, or resolution, is at best 1 part in 999,999 or about 1E−6. Although some computers (such as pocket calculators) operate directly with decimal arithmetic, typically both the exponent and the mantissa are represented by binary numbers.

Most of the computers in use today have one or more of the following for-

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mats for floating-point numbers:

1. Single-precision (32-bit): 8-bit exponent, 24-bit mantissa; resolution = 5.96E−8.
2. Double-precision (64-bit) IBM/DEC style: 8-bit exponent, 56-bit mantissa; resolution = 1.38E−17.
3. Double-precision (64-bit) IEEE style: 11-bit exponent, 53-bit mantissa; resolution = 1.11E−16.

The figures given as "resolution" indicate the smallest number that, when added to the number 1.0, yields a computed result different from 1.0. The values shown are approximate. The relative error of the computer representation of a given number can vary from 0 up to the indicated amount. The term "relative error" is used in a percentage sense: It refers to the error divided by the correct value. "Absolute error" means simply the magnitude of the error itself.

"Round-off error" is the difference between an infinitely precise value and its representation in the finite-length computer-number format. This is the irreducible limit to accuracy in a given computer arithmetic.

In a chain of calculations, the maximum total relative round-off error is estimated conservatively by counting the total number of arithmetic operations and multiplying by the "resolution" figure given above.

This is *not* the maximum possible error of the result, because in addition to round-off there are other purely numerical sources of error. In fact, as we shall see, round-off error is sometimes the least of our worries.

Listing 1: *An inefficient power routine.*

```
double power( x, N )
        double x;
        int N;
        {
        int i;
        double y;
        y = 1.0;
         for( i=0; i<N; i=i+1 )
               y = y * x;
         return( y );
        }
```

$$(1)\qquad e^x = 1 + x + \frac{x^2}{2} + \frac{x^3}{6} + \ldots$$

$$(2)\qquad N = 10{,}000 = 0010\ 0111\ 0001\ 0000 = 2^4 + 2^8 + 2^9 + 2^{10} + 2^{13}$$

$$(3)\qquad x^{10{,}000} = x^{2^4} * x^{2^8} * x^{2^9} * x^{2^{10}} * x^{2^{13}}$$

$$(4)\qquad 2^{x \log_2 e} = \left(2^{\log_2 e}\right)^x = e^x$$

$$(5.1)\qquad a_0 + a_1 x_1 + a_2 x_1^2 + d = f(x_1)$$

$$(5.2)\qquad a_0 + a_1 x_2 + a_2 x_2^2 - d = f(x_2)$$

$$(5.3)\qquad a_0 + a_1 x_3 + a_2 x_3^2 + d = f(x_3)$$

$$(5.4)\qquad a_0 + a_1 x_4 + a_2 x_4^2 - d = f(x_4)$$

$$(6.1)\qquad a_0 + a_1 x_1 - b_0 (f(x_1) + d) = x_1 (f(x_1) + d)$$

$$(6.2)\qquad a_0 + a_1 x_2 - b_0 (f(x_2) - d) = x_2 (f(x_2) - d)$$

$$(6.3)\qquad a_0 + a_1 x_3 - b_1 (f(x_3) + d) = x_3 (f(x_3) + d)$$

$$(7)\qquad \frac{Q(x^2) + x P(x^2)}{Q(x^2) - x P(x^2)}$$

Figure 1: *The equations used in this article.*

ALGORITHM SPEED

The exponential function exp(x) involves finding the xth power of a special number e (2.71828 . . .). Both x and e are floating-point numbers. To warm up to this problem, let's first design a program called "power(x,N)" that will find the Nth power of a number x. N can be any positive 16-bit integer, while x is a real number represented in floating point.

This looks trivial. We can immediately write down the computer code for an algorithm that simply multiplies x by itself N times. (See listing 1. All programs are written in C language, but some of the less obvious C constructions are avoided.) This program can take a relatively long time to execute. If N = 10,000, the for loop will have to be done 10,000 times.

There is a much faster algorithm than this. It can be understood by looking at the binary representation of N, equation 2.

Since adding in the exponent is equivalent to multiplying in the base, we can factor the product of 10,000 x's into equation 3. Are these 2-to-the-nth powers of x easy to compute? Yes, they are. To get them, we just successively square x, square the square of x, and so forth. Using this insight, the program can be revised to look like listing 2.

On each loop, the next binary bit of N is tested. If it is a 1, then the current value of z is one of the factors needed in the expression for the power. To prepare for the next loop, z is squared. Also, the next higher bit

(continued)

of N is shifted down into the ones position, ready for testing by ANDing it with the number 1.

The revised algorithm reduces the number of passes through the loop from 10,000 to only 14. In general the number of passes is on the order of $\log_2(N)$. In addition to being much faster, the smaller number of operations means that this implementation is less subject to the effect of round-off error.

Of course, if N is small, then the original version of the program may be faster. A complete program might test the value of N and then choose one or the other method.

RANGE REDUCTION

Approximating functions often can be used for only a small range of argument values. For example, you might have a table of logarithms that covers arguments from 1 to 10. Outside this range, you must do something that reduces the argument to the tabulated range, then do an inverse something on the tabulated function value in order to get the desired answer.

Let's use the trick described in the previous section to perform range reduction for the exponential function. Suppose there is available a formula for exp(x) for x between 0.0 and 1.0; say we have already written a function called formula(x) to do this. We will split x into an integer part N and a fractional part f in such a way that $x = N + f$, with f between 0.0 and 1.0. The program code for this would be simply N = x; f = x – N; since the needed integer truncation function is invoked automatically by the language compiler. The first expression truncates x to the nearest integer smaller than x; then the second finds the fraction by subtracting off the integer part. Having split x into the sum of its integer and fractional parts, we can write exp(x) = exp($N+f$) = exp(N) * exp(f). We have the subroutine formula( ) (listing 4) for exp(f), so we have only to find exp(N). But this is merely the Nth power of the number e = 2.71828. . . ., or power(e,N). So the solution is immediate: exp(x) = power(e,N) * formula(f).

For a frequently used computer routine we would modify power( ) to avoid having to calculate the squares of squares of e every time the function is called. Since these numbers are constants, we could simply write out a table of the possible values of z in power( ). There would be one table entry for each of the possible bits (16 of them) in an integer. An additional advantage of incorporating a table is that the tabulated values would not be subject to accumulated round-off error but would have full machine accuracy.

Listing 2: *An efficient way of obtaining powers of x.*

```
double power( x, N )
        double x;
        int N;
        {
        double y, z;
        y = 1.0;
        z = x;
         while( N != 0 )
               {
               if( (N & 1) != 0 )
                      y = y * z;
                z = z * z;
               N = N >> 1;
               }
         return( y );
        }
```

Listing 3: A *typical program to compute x modulo m.*

```
double mod( x, m )
        double x, m;
        {
        long n;
        double f;
        f = x/m;
        n = f;
        return( x - n * m );
        }
```

CANCELLATION ERROR

In the above example, we were lucky that a computer number can be split into integer and fractional parts without losing accuracy. The fractional part of x, expressed in more general terms, is x modulo 1. If the modulus of the modulo function were not 1 but a number that cannot be represented exactly in the computer, then we would have been in some trouble.

This problem arises in trigonometry functions such as sines and tangents. Suppose we have sin(x) tabulated for x ranging from 0 to 2π (6.28318. . .). To compute sin(1000) we simply find 1000 modulo 2π and look up the answer directly in the table. However, this is not as easy as it seems because of the limited precision of the modulo function.

A typical program that computes x modulo m is presented in listing 3. The program divides x by the modulus and truncates the quotient to an integer n. This n is the largest whole number for which $m * n$ is less than x. (And so, $m * (n+1)$ would be greater than x.) Hence the answer sought is $x-(m * n)$.

Now to illustrate the problem, assume the computer uses six-place

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decimal arithmetic to find the sine of 1000. Then 2π is represented as 6.28319. The computer finds 1000/6.28319 = 159.154, so n = 159. Hence mod(1000, 2π) = 1000−159 * 6.28319 = 0.967611. The correct answer is 0.973536; the answer produced by mod( ) is in error by nearly 1 percent. This is far from six-decimal accuracy!

The problem with the modulo function is an example of "cancellation error," which is a loss of relative precision on subtracting two floating-point numbers that are nearly equal. This error can be extremely severe. As the two numbers approach each other and become exactly equal so far as the computer is concerned, all relative precision in the arithmetic difference is completely lost.

To improve the situation we could use extended-precision arithmetic in the modulo function. This can sometimes be done without writing a whole new set of arithmetic routines. Illustrating again by a numerical example, let the number 2π (6.283185307179586. . .) be represented as the sum of three special numbers: $2\pi = p1 + p2 + p3$ = 6.28000E0 + 3.18000E−3 + 5.30718. . .E−6. The first two of these numbers are exactly represented in the (decimal) computer. Instead of calculating $x-n * m$, the program mod( ) will calculate $x-n * (p1 + p2 + p3)$ working from left to right in the form $x-n * p1-n * p2-n * p3$. In other words, the computer will find successively 1000−159 * 6.28E0 = 1.48, then 1.48−159 * 3.18E-3 = 0.97438, and finally 0.97438−159 * 5.30718E−6 = 0.973536.

Because this is only an incomplete implementation of a higher-precision arithmetic, its range is limited. The computer can multiply $p1$ by any integer up to 999,999/628 = 1592 and the result will be exact. If x is greater than 1592 * 2π (this is entirely possible, since the numbers are floating point), then the trick won't work; we would have to split 2π into more parts, each having fewer significant figures.

ERROR AMPLIFICATION

In the example of range reduction for the exponential function, there might have been significant cancellation error except for the fact that we were lucky in choosing a modulus that preserves full accuracy. A closely related, though separate, accuracy problem called "error amplification" can be illustrated by doing the range reduction in a slightly different way.

Many commercial library routines for exp(x) actually compute equation 4. This method theoretically produces the same result. It converts the original argument x into an equivalent exponent of 2. The program then splits that exponent into an integer

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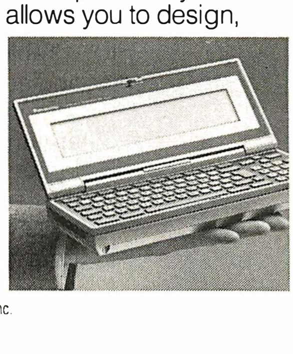


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and fractional part. The number 2 raised to an integer power is computed easily by integer arithmetic on the exponent; this is one reason for converting x to an exponent of 2.

The problem with this is that the conversion factor $\log_2 e$ is not exactly represented in the computer. Therefore the computed exponent of 2 will be in error by a small relative amount. Let's see what trouble this leads to by performing an "error propagation" analysis. Call the above error "epsilon" (ϵ). Instead of calculating exp(x), the routine is really calculating exp(x * (1 + ϵ)) = exp(x) * exp(x * ϵ) = exp(x) * (1 + x * ϵ + . . .). The last expression consists of the first two terms of the infinite series for exp(x) given earlier. The analysis shows that by the time the final result is computed, the error ϵ, which crept into the base-conversion step of the computation, will have been amplified by the factor x. In a typical computer where ϵ = 1.4E−17 and where x can be as high as 88 before overflow sets in, this design tactic increases the relative error from a few parts in 10^{17} to more than one part in 10^{15}.

APPROXIMATION FUNCTIONS

We now have all the pieces for an exponential function program except a formula for exp(x) when x is between 0.0 and 1.0. To start with, let's examine the infinite-series expansion shown in the introduction and attempt to use it directly for this purpose.

Series expansions are very important, even though they are used only occasionally in finished library routines. The basic method of expressing and evaluating transcendental functions is in terms of infinite series (sometimes involving sequential multiplications or divisions as well as summation). To find an approximate expression for computation, it is necessary to have some accurate values of the function in order to design and test the approximation. These accurate values are found by reverting to a series expansion computed in high-precision arithmetic.

Let's now write a program to sum the infinite series for exp(x). The particular series shown for the exponential function (known as a Taylor series) contains in its nth term the nth power of x in the numerator and the factorial of n in the denominator. Having arrived at a given term in the series, we will have already calculated both items in the previous term but with n reduced to $n-1$. The factorial is easily calculated by multiplying the factorial of $n-1$, found in the previous term, by n. Similarly, the nth power of x is just x times the $(n-1)$th power of x, also found in the previous term. For n = 0 the factorial is 1. The 0th power of x is also 1. Hence the series expansion can be evaluated by a simple loop (listing 4). The loop may certainly be terminated at the point where term is so small compared to sum that adding it in the computer will not change the value of sum. The error of the result will usually be larger than TINY, though, due to round-off error in accumulating the sum. In this example cancellation error is not dominant because all the terms are positive; there is no chance of subtracting two nearly equal numbers. Table 1 shows the value of n (i.e., the number of items added up) at termination and the relative error of the sum for several values of x. For comparison, the error of a library routine for exp(x) is also shown. In this experiment the arithmetic employed IBM/DEC-format numbers, which have a resolution of 1.38E−17. All of the indicated errors are relative to the output of a high-precision "check routine" that in this experiment was accurate to about 43 decimal places. In the interval between 0 and 1, the maximum error of our program formula( ) appears to be about twice that of the library routine. In fact, the approximation used in the library routine requires only about half as many operations as formula( ), so it has correspondingly less round-off error.

You must realize that table 1 shows only a very few samples of the error, and the result for some value of x not shown might have considerably higher error. A better experimental test would be to evaluate the error at a large number of pseudorandom arguments. This test was carried out at 1000 arguments for both approximations; the maximum error found between 0 and 1 for formula( ) was 9.6E−17 and for the library routine, 4.0E−17.

Table 1 illustrates several important and general points. First, the error of formula( ) increases as the range of arguments to be handled becomes large. Second, there is a point (0 in this case) where convergence is rapid; however, the amount of computation time increases as the argument

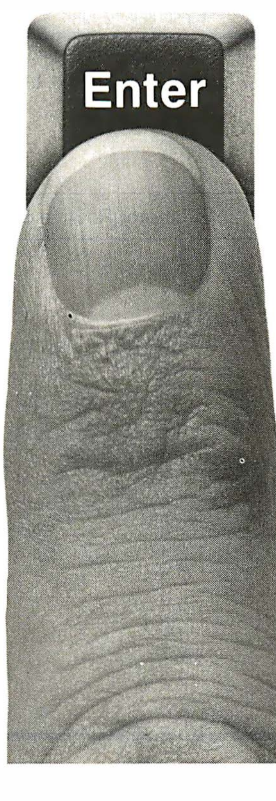
(continued)

Listing 4: A *Taylor-series expansion for finding exp(x).*

```
#define TINY 1.38E-17
        double formula(x)
                double x;
                {
                double n, sum, term;
                n = 0.0;
                sum = 1.0;
                term = 1.0;
                do
                        {
                        n = n + 1.0;
                        term = term * (x / n);
                        sum = sum + term;
                        }
                while( (term / sum) > TINY );
                return( sum );
                }
```

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moves away from that point. These are good reasons for performing range reduction on the argument.

Third, the errors are seemingly random and are within the bounds predicted by round-off analysis. Both programs have theoretical error: The series summation was truncated after a certain number of terms, and the algebraic polynomial formula used in the library routine has an error that can be computed analytically. In each case, the typical actual error is greater than the theoretical error, due to the effects of limited arithmetic precision.

In formula( ) we used an exact defining power series for the exponential function. The library routine employs an algebraic function that is only an approximation to the exact analytic function exp(x). Yet the library routine is both faster and more accurate than the series-summation method. This fact supplies the motivation for using and thinking about special approximating functions in numerical routines.

POLYNOMIAL APPROXIMATIONS

A basic function available for computer approximation is the polynomial of degree N (where N is the highest power of the argument x in the polynomial). If the infinite series for exp(x) were stopped at, say, the term in x to the 19th power, the series would be just a polynomial of degree 19. However, this is not the best polynomial of degree 19 that we could use. Our objective will now be to adjust the $N+1$ coefficients of the polynomial so as to achieve the best fit to a given function. If "best" means that the worst-case deviation is made as small as possible, then the following conditions, discovered by Chebyshev, apply: For a general (continuous) function $f(x)$ in a given range of x, a particular polynomial of degree N can be found such that (1) the function and the polynomial agree exactly for at least $N+1$ values of x, (2) it can be arranged that the graph of the polynomial oscillates back and forth over the graph of the function, being first greater, then less, than the function (there will be at least $N+2$ values of x where the error, or deviation, is a local maximum), and (3) it can be arranged that all of the $N+2$ locally maximum deviations have exactly the same magnitude.

A polynomial having all three of these characteristics is a "least maximum" approximation to the function. The worst-case deviation will be as small as it can possibly be for a polynomial of that degree.

Such a polynomial can be found by an iterative procedure that eventually converges to the desired result. The procedure depends on our being able to set up and solve a set of equations that assume that the above three properties are true.

Equations 5.1 through 5.4 are the equations for a polynomial of degree 2 that is to approximate the function $f(x)$. The polynomial has three coefficients, denoted by a with a subscript ranging from 0 up to the degree 2 of the polynomial. If we evaluate the polynomial at some point x, then f(x) equals the value of the polynomial plus or minus the deviation (labeled d in the equations). For a polynomial of degree 2, there are four ($N+2$) such values of x where the deviations are all equal, so we can set up four of these equations. In two cases the deviation is positive, while in the other two it is negative.

According to the third property stated above, the deviation at all four places should be a local maximum. The equations do not reflect this property, which is the reason for the technique being iterative.

Although we don't know where the extreme deviations will occur, we will put in four trial guesses for the four values of x. These should all be in the interval over which we want the approximation to be accurate. The unknowns in the equations are then the polynomial coefficients, labeled a, and the deviation d. The equations are linear, since only the first power of the unknowns occurs, and there are no cross terms. Therefore, we have a set of linear simultaneous equations in four unknowns to solve.

I have provided a program to solve systems of linear equations. [*Editor's note: All programs discussed or listed in this article are available in* C *source code on disk in a variety of formats as explained on page* 346. *They are also obtainable by downloading from* BYTE*net Listings at* (617) 861-9764.] Limited space prevents a digression

(continued)

Table 1: *Exponential-function approximation errors for listing 4 compared to a library routine's errors.*

Exponential Function Approximations

x	n	Series Sum Error	Library Routine Error
0.0	1	0.0E-17	0.0E-17
0.1	11	2.9	2.9
0.2	12	0.6	1.6
0.3	14	3.6	1.5
0.4	15	3.7	1.9
0.5	16	0.5	1.2
0.6	16	0.7	2.2
0.7	17	5.2	2.8
0.8	18	0.7	1.8
0.9	18	0.9	1.4
1.0	19	4.9	2.9
2.0	24	2.4	2.4
4.0	31	4.5	2.9
8.0	43	4.7	0.9
16.0	61	4.5	1.9
32.0	91	7.6	2.7
64.0	143	15.4	2.2

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into this interesting topic, so let's just use the program and not worry about how it works.

Having solved the equations, we can evaluate the polynomial, using the coefficients found by the equation solver, at various values of x in the range over which we want the approximation to be optimum. We should find that the deviation at the four trial values of x is equal to d, as returned by the equation solver.

However, we will find that there are places where the deviation is greater than d. This can happen because there is nothing in the equations to say that d is the maximum of anything. Looking at a chart of the deviation, we find the values of x at which the deviation actually is locally maximum. These values are used as the next trial guesses for insertion into the set of equations.

If the initial guesses are sufficiently close, the procedure will converge in a very few iterations to a condition in which the extreme deviations actually do occur at the values of x that we have guessed, and there are no deviations greater than d. The resulting coefficients a are those of the least maximum polynomial approximation to $f(x)$, for a polynomial of the given degree N. This overall procedure is known as the second algorithm of Remes.

There is a way of making initial guesses that are often extremely close to the optimum trial values of x. If the start of the approximation interval is at $x = s$ and the width of the approximation interval is w, then the magic values are $x_i = s + 0.5w(1-\cos(i\pi / N+1))$ where i takes on the $N+2$ values 0, 1, ..., $N+1$. These guesses are frequently so good that "for engineering purposes," as the saying goes, there is little need to continue with another iteration. The indicated values of x are the points at which the *Chebyshev polynomial* (see the text box entitled "Chebyshev Approximations" on page 174) of degree $N+1$ takes on its extreme values. The error curve for a best-fitting polynomial of degree N frequently looks like the Chebyshev polynomial of degree $N+1$, which is why these are good values to try.

An interactive program to implement the Remes algorithm is available as specified above. Using it to approximate the exponential function with a polynomial of degree 2, we get the results shown in the figures. Figure 2 shows exp(x) for x ranging from 0 to 1. Also shown in the same figure is the best-fitting polynomial of degree 2. The error is less than 0.01, so the drawing shows at best a slight thickening of the line in several places.

Figure 3 illustrates the approximation error, greatly magnified for visibility. For comparison, figure 4 shows the Chebyshev polynomial of degree 3. You can see that the curves are very similar in shape, except for the sign reversal.

RATIONAL APPROXIMATIONS

We are now in a position to design the most commonly used computer approximations, called "rational functions." A rational function is the ratio of two polynomials. For a given amount of calculation, rational functions tend to produce closer theoretical approximations than polynomials. (Sometimes the theoretical advantage is lost due to numerical instability.)

If $P(x)$ and $Q(x)$ are two polynomials, the equation for approximating $f(x)$ by their ratio is $P(x)/Q(x) = f(x) + d$, or $P(x) - (f(x) + d)\ Q(x) = 0$. Again, d is the deviation between $f(x)$ and the approximation $P(x)/Q(x)$. Reasoning as before, we can form a set of simultaneous equations to be solved for the coefficients of the two polynomials.

The equations when both $P(x)$ and $Q(x)$ are first-degree polynomials are shown in equations 6.1 to 6.3. The coefficients of the numerator polynomial $P(x)$ are labeled a with a subscript. The coefficients of the denominator polynomial $Q(x)$ are labeled b with a subscript. Since we can multiply both sides of the equation by a constant without affecting the equality, the leading coefficient of $Q(x)$ (i.e., its coefficient of x to the highest power) may be set equal to 1 without affecting either d or $f(x)$. This

(continued)

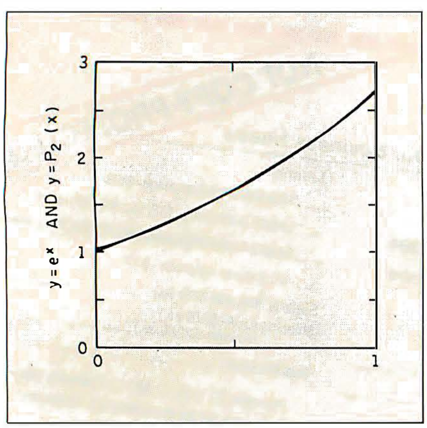


Figure 2: *A graph of exp(x) for x=0 to 1. Included is the best-fitting polynomial of degree 2.*

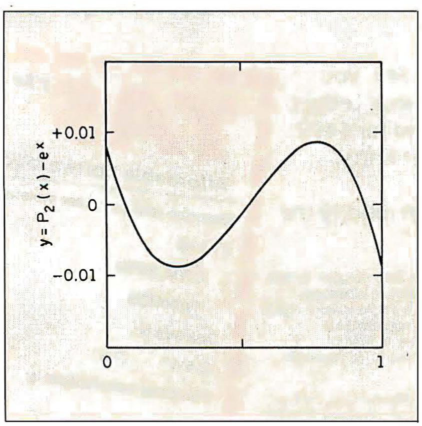


Figure 3: *The approximation error in figure 2, magnified greatly for visibility.*

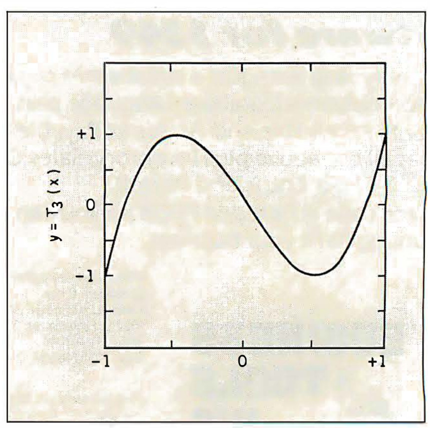


Figure 4: *A graph of the Chebyshev polynomial of degree 3.*



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Chebyshev Approximations

Three conditions satisfied by a least maximum polynomial approximation were stated in the main text on page 170. If a polynomial satisfies all but the third condition, it is called a "nearly least maximum" approximation. Typically, error leveling carried out on such a polynomial accomplishes only a slight improvement in accuracy. Chebyshev polynomials yield a nearly least maximum approximation under most circumstances. Thus they are useful in such optimization situations as the design of digital and analog filters. Chebyshev expansions also tend to be numerically stable, in the sense that they do not suffer from cancellation-error problems. For this reason they may be found in actual library routines in cases where other forms of approximation are less stable.

Chebyshev expansions bear a somewhat magical relation to Fourier-series expansions. In fact, to compute the coefficients of the Chebyshev expansion, we will evaluate the Fourier series of the function $f(x)$ using values of x that are not evenly spaced.

The family of Chebyshev polynomials is defined by equations a, b, and c (all equations designated by letters appear in figure A) and the general term can be found by the recurrence in equation d. Figures 4 and 7 in the main text show two of these polynomials. The argument x is considered to range between -1 and $+1$. Other desired intervals can be mapped into this range by a linear transformation of the input argument x.

(a) $T_0(x) = 1$

(b) $T_1(x) = x$

(c) $T_2(x) = 2x^2 - 1$

(d) $T_{n+1}(x) = 2 * T_n(x) - T_{n-1}(x)$

(e) $f(x) = \sum_{k=0}^{\infty}{}' a_k T_k(x)$

(f) $a_k = \frac{2}{\pi} \sum_{j=0}^{N}{}'' f(\cos(j\pi/N)) \cos(jk\pi/N)$

(g) $T_k(x) = \cos(kj\pi/N)$

(h) $T_n(x) = \cos(n \arccos(x))$

(i) $T_n(x) = \cos(nz)$

(j) $\cos((n+1)z) = 2\cos(z)\cos(nz) - \cos((n-1)z)$

(k) $\cos(A+B) = \cos A \cos B - \sin A \sin B$

(l) $f(x) = \sum_{k=0}^{M}{}' a_k T_k(x)$

Figure A: *The equations used in the text box.*

Each of these polynomials crosses the x axis n times and has $n+1$ local extrema, all of which occur at the same value of deviation from the x axis. These are just the conditions for the error curve of a best approximation of degree $n-1$.

Suppose the coefficients of a Chebyshev polynomial expansion decrease fairly rapidly with n, so that the error after $n-1$ terms can be approximated by the nth term (i.e., ignoring the contribution of later terms). Then, the error has close to the least maximum properties, and the approximation to $n-1$ terms is close to a least maximum approximation.

To expand a function $f(x)$ in terms of Chebyshev polynomials, we want to find the coefficients in the formula given in equation e. By a shorthand convention, the prime (′) over the summation sign indicates that the first term is to be divided by 2 (this is done to make the formulas a little more compact). If we stop the summation at $k=n$, the result is a polynomial of degree n.

The Chebyshev coefficients of the function $f(x)$ may be found from the formula in equation f. The double prime (″) over the summation sign indicates that the first and last terms are to be divided by 2. This formula is the same as the Fourier cosine transform of the function $f(x)$, except that $f(x)$ is evaluated at the points $\cos(j\pi/N)$, which are not evenly spaced.

The "real" Chebyshev coefficients are obtained by letting N increase to infinity in equation f, so that the sum becomes an integral. This is analogous to the relation between the discrete and continuous Fourier transforms. In our situation, we cannot say that $f(x)$ is a spectrally band-limited function, so the behavior of the function between the sampled values of x cannot be disregarded so readily. For the error to be negligibly small, N should be considerably larger than the desired degree n of the approximation polynomial.

Since $f(\cos(j\pi/N))$ and the Chebyshev coefficients are a Fourier transform pair, the expression of $f(x)$ in terms of Chebyshev polynomials must be the in-

verse of this Fourier transform. Therefore, it must be true that when $x = \cos(j\pi/N)$, then equation g. We could then be tempted to substitute $j\pi/N = \arccos(x)$. As N increases to infinity, the equation would indeed be valid for any x. In fact, an alternate definition of the nth Chebyshev polynomial is equation h. It is not obvious that this expression is even a polynomial! However, putting $n=0$ yields $\cos(0)=1$, and $n=1$ yields $\cos(\arccos(x)) = x$. To see that this definition is equivalent to the original one, substitute $z = \arccos(x)$. Then we have equation i, and for the recurrence formula for the polynomials to be true, we want equation j to be a trigonometric identity. Using the identity equation k, you can show that this is correct.

Thus the Fourier series for the Chebyshev coefficients leads to the expression for $f(x)$ in terms of Chebyshev polynomials, with the proviso that N be sufficiently large.

I have provided a C program, as explained in the main text, that will evaluate the Chebyshev polynomial expansion coefficients for a given function $f(x)$. Once the coefficients have been found, they may be substituted into equation 1 to obtain an approximation for $f(x)$. Summation of the series stops at the Mth term, where M is whatever we choose. If all the terms were rearranged and collected by powers of x, the result would be a straightforward polynomial of degree M. The summation can also be carried out directly from the expansion coefficients by using the listing A program.

Listing A: *A subroutine to evaluate a Chebyshev polynomial expansion up to the Mth-order term.*

```
/*
This subroutine evaluates a Chebyshev polynomial
expansion up to the Mth-order term, given the
argument "x" and an array "array[M+1]"
containing the Chebyshev expansion coefficients.
To achieve maximum execution speed, the routine
is designed so the coefficients must be stored
in reverse order, with the Mth order coming
first and the 0th order last.
*/

double chbevl( x, array, M )
double x;
double array[];
int M;
{
double b0, b1, b2, *p;
int i;
p = array;
b0 = *p++;
b1 = 0.0;
x *= 2.0;
i = M - 1;
do
        {
        b2 = b1;
        b1 = b0;
        b0 = x * b1 - b2 + *p++;
        }
while( --i );
return( 0.5*(b0-b2) );
}
```

The number of equations to be solved is equal to $N+D+1$.

term, multiplied by $f(x) + d$, has been moved over to the right side of the equations since it will be treated as constant.

Although there are four unknowns (two a's, one b, and the deviation d), only three equations are shown. The reason is that all of the b's are multiplied by a factor that includes d; the product of b times d is a nonlinear term. Therefore the equations would not be linear if we considered d to be an unknown. So, to make the equations easy to solve, we are going to have to guess not only the three values of x, but also a value for d.

Suppose $P(x)$ is a polynomial of degree N (for "numerator"), and $Q(x)$ is a polynomial of degree D (for "denominator"). The number of equations to be solved is equal to $N+D+1$.

In the previous section it was noted that the error curve for approximation by a polynomial of degree N is often similar in appearance to the Chebyshev polynomial of degree $N+1$. In the present situation we can again make the job of guessing trial values easier, this time by making use of the Chebyshev polynomial of degree $N+D+1$.

While the Chebyshev polynomial may have the right shape, its extreme values are just $+1$ or -1. This gives us no help in guessing the extreme values of d for our particular deviation function. However, there is a way out. We could just as well set $d = 0$ in the equations and use for x the points at which the Chebyshev polynomial is equal to 0! This will leave the actual extreme deviation somewhat uncontrolled, but we will at least have a starting point for the iterative procedure.

For this situation the magic values

(continued)

of x, the "zeros" of the Chebyshev polynomial of degree $N+D+1$, are at $x_i = s + 0.5w\ (\ 1-\cos(\ 2(i-1)\ \pi\ /\ 2(N+D+1)\ )\ )$, where i takes on the values 1, 2, . . . , $N+D+1$. The iterative procedure begins by substituting these values of x, along with the value d=0, and solving the set of linear equations. This gives us the coefficients (the a's and b's) of the numerator and denominator polynomials of the rational approximation. As in the previous situation, the result is frequently so close to the final optimum that there is little point in going on with a second iteration.

If we do decide to continue, there are two basic strategies for leveling the error extrema: (1) adjust the points at which the error is 0 and continue to set d=0, and (2) use $N+D+1$ of the $N+D+2$ points where the error is locally maximum and, by looking at the error data, guess a value for the maximum error d. Each of these strategies has its adherents.

You can sometimes subtract away a function's difficult behavior around critical values.

```
Rational Approximation by Remes Algorithm
     Relative error (y or n) ? y
   Degree of numerator polynomial? 4
   Degree of denominator polynomial? 4
   Start of approximation interval ? -0.5
   Width of approximation interval ? 1.0
   deviation = 0.0000e+00 ?
     x[0] = -4.9240e-01 ?
     x[1] = -4.3301e-01 ?
     x[2] = -3.2139e-01 ?
     x[3] = -1.7101e-01 ?
     x[4] = 0.0000e+00 ?
     x[5] = 1.7101e-01 ?
     x[6] = 3.2139e-01 ?
     x[7] = 4.3301e-01 ?
     x[8] = 4.9240e-01 ?
       Numerator coefficients:
   1.0000e+00  5.0000e-01  1.0713e-01   1.1897e-02   5.9391e-04
   Denominator coefficients:
              -5.0000e-01  1.0713e-01  -1.1897e-02   5.9391e-04
                   x         func         approx        error
              -5.000e-01   6.065e-01    6.065e-01    3.015e-13
              -4.500e-01   6.376e-01    6.376e-01   -1.829e-13
              -4.000e-01   6.703e-01    6.703e-01    2.650e-13
              -3.500e-01   7.047e-01    7.047e-01    1.924e-13
              -3.000e-01   7.408e-01    7.408e-01   -1.417e-13
              -2.500e-01   7.788e-01    7.788e-01   -2.998e-13
              -2.000e-01   8.187e-01    8.187e-01   -1.597e-13
              -1.500e-01   8.607e-01    8.607e-01    1.164e-13
              -1.000e-01   9.048e-01    9.048e-01    2.907e-13
              -5.000e-02   9.512e-01    9.512e-01    2.347e-13
               0.000e+00   1.000e+00    1.000e+00   -2.776e-17
               5.000e-02   1.051e+00    1.051e+00   -2.347e-13
               1.000e-01   1.105e+00    1.105e+00   -2.907e-13
               1.500e-01   1.162e+00    1.162e+00   -1.164e-13
               2.000e-01   1.221e+00    1.221e+00    1.597e-13
               2.500e-01   1.284e+00    1.284e+00    2.998e-13
               3.000e-01   1.350e+00    1.350e+00    1.417e-13
               3.500e-01   1.419e+00    1.419e+00   -1.924e-13
               4.000e-01   1.492e+00    1.492e+00   -2.651e-13
               4.500e-01   1.568e+00    1.568e+00    1.829e-13
               5.000e-01   1.649e+00    1.649e+00   -3.015e-13
   Another iteration (y or n)?
```

Figure 5: *An interactive session with the author's Remes program. The approximation is for the exponential function.*

Taking Advantage of Analytical Behavior

Sometimes it is possible to find a trick that will reduce the degrees N and D of the rational approximation that satisfies a given error condition. The trick may be in the behavior of the function or in the rational approximation itself.

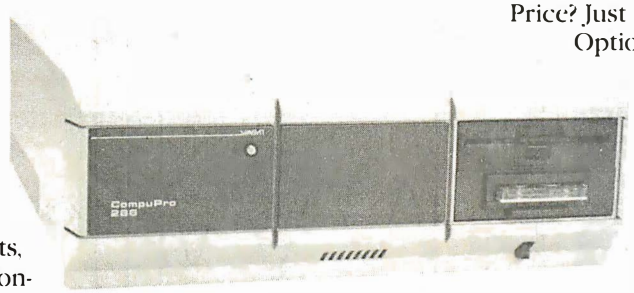
Many functions are very unpolynomial-like near critical values of the argument such as 0 or infinity. This may make it difficult to achieve a good rational approximation. In such cases it is wise to try factoring out or subtracting away the difficult behavior by searching for a simple expression that represents the function's limiting or asymptotic behavior. For example, a function $f(x)$ that behaves like a square root near x=0 might be approximated as $\sqrt{x} * P(x)$. In that case, the function that the polynomial $P(x)$ would be asked to approximate is $f(x)/\sqrt{x}$.

The exponential function has the interesting property that $\exp(-x) = 1/\exp(x)$. This suggests that some kind of antisymmetry might appear if we were to take the interval of approximation to be symmetrical around x=0. Figure 5 shows in detail what happens when we make the interval go from -0.5 to $+0.5$ and solve for a rational approximation with $N = D = 4$. The coefficients of the numerator and denominator polynomials become the same, except for a difference in the signs! A few moments' study of this situation will show that

(continued)

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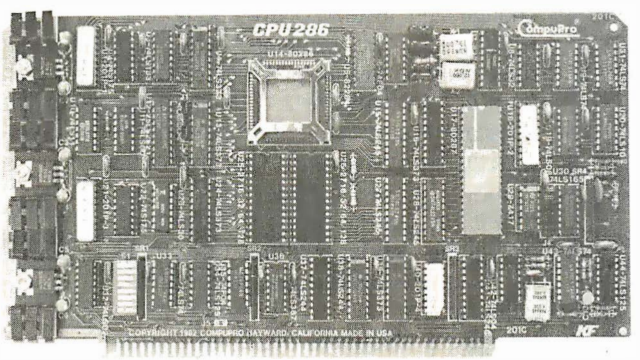
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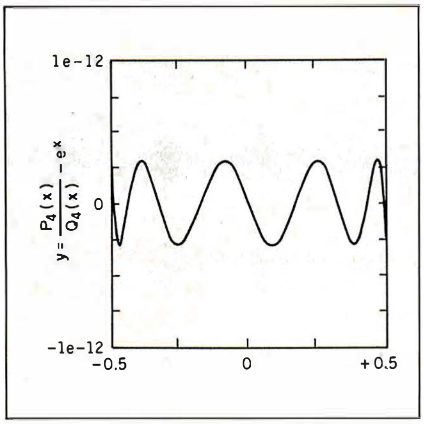


Figure 6: *The error curve for the approximation solved in figure 4.*

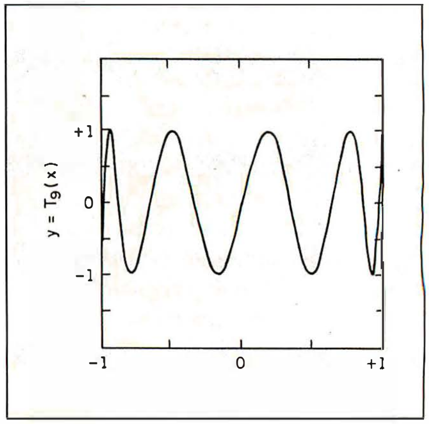


Figure 7: *The Chebyshev polynomial of degree 9.*

this approximation can be rearranged to have the form shown in equation 7, where $P(x)$ consists of the terms originally having minus signs in the denominator polynomial, and $Q(x)$ comprises the terms that did not change sign. Instead of evaluating two fourth-order polynomials, we now have only to evaluate $P(x)$ of degree 1 and $Q(x)$ of degree 2. This yields a substantial saving in computation for exactly the same result. This approximation is called a Pade form. Note that it has just the property we noted about the exponential function, that its value at $-x$ is the reciprocal of its value at $+x$.

Figure 6 illustrates the error curve for the approximation solved in figure 4. Again for comparison, Figure 7 shows the Chebyshev polynomial of degree 9.

IMPLEMENTATION ISSUES

We have now touched on all the theoretical design problems of computer approximation. Some additional problems arise in the environment of practical application. These are important to a programmer who is trying to get the function routines to work. However, since each machine and each compiler has its own peculiarities, there is little advice that can be offered in the abstract.

Good workmanship demands that any numerical routine be carefully tested and checked for possible arithmetic overflow and underflow conditions that might render the answer meaningless. Alarm exits for these conditions must be programmed for the particular system in use.

A final note of warning: To achieve maximum accuracy, both the expansion coefficients and the test values of a function should be calculated using arithmetic having greater precision than the arithmetic of the intended routine. ■

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THE INVERSION OF LARGE MATRICES

BY THOMAS E. PHIPPS JR.

The Pan and Reif algorithm provides a solution

A NEW METHOD for inverting matrices was recently discovered by Victor Pan of the Computer Science Department of the State University of New York at Albany and John Reif of the Aiken Computation Laboratory at Harvard (see references 1 and 2). Their main concern was with parallel processing, but the mathematical algorithms they propose work perfectly well with serial processing; all you need is time. Whatever computer you have on your shelf will do very well for testing the method. Using what was on my own shelf, I have inverted several dense (all entries nonzero) random-number-entry matrices of maximum dimension 60 by 60 in total times varying from 15 to 24 hours.

The matrix size limitation $n = 60$ is imposed solely by an artificiality of the particular BASIC language I use: My Toshiba T300 computer (8088 processor, 6-MHz clock, no coprocessor) came from the mail-order discounter bundled with a dialect known as TBASIC that arbitrarily limits me to about 60K bytes of RAM, even though the machine was never sold with less than 192K bytes and accommodates 256K bytes on the motherboard. If you are lucky enough not to be "software-bound" or can write your own assembly- or machine-language programs, the sky is the limit on what you can do in this era of cheap memory chips.

Large-matrix inversion is very RAM-demanding, but nothing fancy in the way of either hardware or software is needed to test the present approach, since the algorithm I shall describe is numerically stable—that is, "self-healing"—and works fine in single precision.

Let's begin at the beginning. A *matrix* A is a two-dimensional array of real or complex numbers, known as its "elements," $A(I,J)$; $I = 1,2, \ldots ,n$; $J = 1,2, \ldots ,n$. If a matrix is square (that is, of dimensions n by n) and nonsingular (that is, not in some sense equivalent to zero), it possesses an inverse matrix A^{-1} such that $A^{-1}A = AA^{-1} = I$, where I is the n by n "unit matrix" having ones on its main (upper left to lower right) diagonal and zeros elsewhere. The problem is: Given A, what is A^{-1}? If the dimension n of A is small, this problem is easy. But if n gets even as large as 10, classical methods become very cumbersome. If n becomes as large as 50 or so, home computers tend to poop out.

The Pan and Reif approach removes all limits except those set by available time and RAM. The underlying mathematical idea of their method involves iteration: Suppose, given the nonsingular n by n matrix A, that we approximate its inverse by a similar matrix B, $A^{-1} \approx B$, and define an "error matrix" of the form shown in figure 1, equation 1. (All equations not in the text are in figure 1. They will be identified by equation numbers appearing in parentheses to the left of the equations.)

By the rules of matrix multiplication we have the identity shown in equation 2. If $E(B)$ were a number x of magnitude $x < 1$, we know by the binomial theorem that we could write

(continued)

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equation 3. It happens that a "norm" q can be defined for a matrix that is analogous to the magnitude of our number x (see reference 1). So, if the matrix B is in some sense a "good enough" approximation to A^{-1}, the norm q of the error matrix $E(B)$ will be less than unity and we can write equation 4 by analogy with equation 3.

Using this device of formal expansion as a guide and introducing an iterative index h (h = 1,2, . . .), we have for iteration h an error matrix (equation 5) by analogy with equation 1. Since B_0, B_1, B_2, . . . is a sequence of matrices that approximate increasingly well (we hope) to A^{-1} as iteration proceeds, we can replace A^{-1} on the left side of equation 4 by the refined approximation B_h, and we can interpret the B appearing on the right side as the less-refined approximation B_{h-1}. Thus equation 4 yields equation 6.

Finally, on entering properly into the spirit of rough approximation, we note that the higher powers of E_h (for $q < 1$), being smaller than the first power, can be dropped, yielding equation 7.

This form is known as *Newton's iteration* (gets around, doesn't he?). For 50 years numerical analysts have shunned it because, to make it work, one needs a "good enough" initial approximation matrix B_0 so that $q < 1$ from the start. Otherwise, the iterative process is prone to diverge. Since no way was known of evaluating B_0, the method was of limited practical value.

The Pan-Reif breakthrough consists of the discovery of a simple and reliable way of evaluating B_0, the initial approximation to A^{-1}, which can safely be used for starting Newton's iteration or variants of it. Readers interested in a derivation can consult the references. I give here merely one example of the results. Let me denote the "Hermitian transpose" of A by A^H. That is, if $A(I,J)$ is the element in the Ith row and Jth column of the A matrix, then $A^*(J,I)$ is the element at the corresponding position in the matrix A^H. Here the star denotes complex conjugate (i.e., if an element is $x + iy$, where x and y are real numbers, then the complex conjugate of that element is $x - iy$). If, as is the case to which I have limited all my own calculations, the elements of A are *all* real, then A^H is just the transposed matrix A^T of A (wherein elements are interchanged or "reflected" with respect to the main diagonal).

We now introduce a number t, defined by equation 8. In words: We consider the *magnitudes* of the various elements $A(I,J)$ of the given A matrix that is to be inverted. (In the case of

(1) $$E(B) = I - BA$$

(2) $$A^{-1} = (A^{-1}B^{-1})B = (BA)^{-1}B = (I - E(B))^{-1}B$$

(3) $$(1 - x)^{-1} = \frac{1}{1-x} = 1 + x + x^2 + x^3 + \ldots, \text{ for } x < 1$$

(4) $$A^{-1} = (I + E + E^2 + \ldots)B, \text{ for } q < 1$$

(5) $$E_h = I - B_{h-1} A$$

(6) $$B_h = (I + E_h + E_h^2 + \ldots)B_{h-1}$$

(7) $$B_h = (I + E_h)B_{h-1}$$

(8) $$t = \frac{1}{(\max_I \Sigma_J |A(I,J)|)(\max_J \Sigma_I |A(I,J)|)}$$

(9) $$B_0 = t\,A^H$$

(10) $$Q_h = (I + E_h + E_h^2 + \ldots + E_h^m), \text{ for integer } m$$

(11) $$B_h = (I + Q_hE_h)B_{h-1}$$

(12) $$Q_{hii} = 1 + E_{hii} + \ldots + E_{hii}^m = \frac{1 - E_{hii}^{m+1}}{1 - E_{hii}}$$

(13) $$Q_{hii} = 1 + E_{hii} + \ldots + E_{hii}^4$$
$$= 1 + (1 + (1 + (1 + E_{hii})E_{hii})E_{hii})E_{hii}$$

Figure 1: *Equations used in the article.*

1. Form the Hermitian transposed matrix A^H having elements $A^*(J,I)$.

2. Evaluate the row sums and the column sums of the magnitudes of the elements of A, take the product of the largest row sum t_1 and the largest column sum t_2, and equate the reciprocal of that product to t,

$$t_1 = \max_I \Sigma_J |A(I,J)|,\ t_2 = \max_J \Sigma_I |A(I,J)|,\ t = \frac{1}{t_1t_2}.$$

3. Let $B_0 = t\,A^H$.

4. Let $E_h = I - B_{h-1}A$, $h = 1,2, \ldots$

5. Newton's iteration: Let $B_h = (I + E_h)\,B_{h-1}$, $h = 1,2, \ldots$

6. Cycle iteratively through steps 4 and 5 until all entries of the error matrix E_h pass some criterion of smallness of their magnitudes. When that occurs, B_h will represent a satisfactory approximation to the desired inverse matrix A^{-1}.

Figure 2: *An outline of the Pan and Reif method discussed in the article.*

a complex element $x + iy$, its magnitude is $\sqrt{x^2 + y^2}$. In the case of a real element, it is just its unsigned or absolute value.) We add up the magnitudes of the elements in a given row and record the sum. We do the same for the remaining rows and then compare the sums thus obtained. The largest of these row sums—just a number—is designated $\max_{I} \sum_{J} |A(I,J)|$. We do the same for the column sums and take the product of these two maxima, designating its reciprocal as the real number t. Finally, we define our initial approximate inverse matrix B_0 as shown in equation 9.

That is, the number t multiplies every element of the Hermitian transpose of the A matrix. Pan and Reif give alternative forms, but this will do. And that's all there is to it.

Figure 2 summarizes the algorithm for inverting a nonsingular square matrix A having given elements $A(I,J)$.

The form of the Pan-Reif procedure presented in figure 2 uses Newton's iteration. The references cited give other forms and iterations, but this one is simple and effective. I found it worthwhile, however, to experiment a bit with refinements to step 5 in the figure 2 iteration. For example, referring back to equation 6 and defining Q_h as in equation 10, we see that an iteration of greater accuracy might take a form such as that of equation 11. For $m \geq 1$ in equation 10, this reduces the number of iterations required for convergence, but because all the extra matrix multiplication increases the time per iteration disproportionately, the net result is a slower inversion algorithm. However, there is a trick of rough approximation to Q_h in equation 10 that does give some speed improvement over the raw Newton's iteration—not a great deal, but worth exploiting and easy to program. No doubt the reader can play with this sort of thing and discover further improvements.

My refinement rests on the observation that the initial error matrix E_h defined by equation 5 is typically not far different from a unit matrix; that is, it has entries on the main diagonal that are slightly less than unity and off-diagonal entries that are quite small with respect to unity. That being the case, a big improvement in initial convergence rate can be achieved by treating the off-diagonal elements of E_h as zero, in approximating the matrix Q_h. Such approximation is a relatively quick and easy calculation because only the n diagonal elements of E_h and powers of those elements are involved. Thus, instead of an extra n by n storage matrix to hold the information in Q_h, we need only one n-element array. This need not be ad-

(continued)

ditional to the basic n by n matrices A, B, E, and X required for Newton's iteration. (The extra storage matrix X is needed to hold temporarily the product on the right side of equation 11 until it can be loaded back into B, it being generally impermissible in BASIC to write a matrix equation, $B = E*B$, in which the same matrix B appears on both sides of the equals sign. Any row or column of the X matrix will do to store the extra n pieces of data just mentioned.)

We have thus agreed, as an approximation, to diagonalize Q_h and the matrices E_h from which it is formed. This means, if we designate the ith diagonal element of Q_h as Q_{hii} and of E_h as E_{hii}, that we can manipulate these numbers just as in school algebra to get equation 12.

Consequently, the only nonvanishing entries of our approximate Q_h matrix are the n numbers given by equation 12 for $i = 1,2, \ldots ,n$. The Q factor gives enough refinement of the Newton iteration to speed initial convergence without significantly penalizing later convergence (when *all* elements of the error matrix E_h become small and of comparable magnitudes, so that all higher powers of E_h become comparatively negligible). The choice of m must be handled with some delicacy. If m is too large (say, greater than 10), the initial rate of reduction of the diagonal elements of the error matrix is excessive, the attendant increase of off-diagonal errors is also too rapid, and the resulting instability can cause divergence of the subsequent iterative process. Empirically, I find values $m = 4$ or 5 generally give best results, and for simplicity I have written my present sample program (listing 1) with $m = 4$. Rewriting equation 10 for this case yields equation 13. [*Editor's note: The* BASIC *program is available on disk as explained on page* 346 *or may be downloaded from* BYTE*net Listings at* (617) 861-9764.] A more versatile program can be written with m an adjustable input parameter and Q_{hii} given by equation 12.

The Pan-Reif algorithm, with the Q-factor modification just described, as programmed in Microsoft BASIC, is shown in listing 1. For convenience of numerical experimentation and to avoid having to input great amounts of made-up data, I have at line 140 generated a random-entry A matrix, to be inverted, the entries of which are real numbers between 0 and 1. At step 150 a randomly chosen algebraic sign is assigned to each entry, with equal probability of plus or minus. (Any real-number matrix can be expressed in this fractional-element form by dividing all elements by the magnitude of the largest element.) The program is readily modified to allow user input of A-matrix entries.

At lines 190 through 210 the row and column sums of absolute values of the A-matrix entries are calculated and temporarily stored in row matrices $X(1,I)$ and $E(1,I)$. These "lists" are then sorted for entry size at lines 220 through 230 and the maxima, $T1$ and $T2$, are used at line 240 to evaluate T—the quantity t in our above discussion. The initial matrix B_0 is evaluated at line 260, and the main iteration comprising lines 280 through

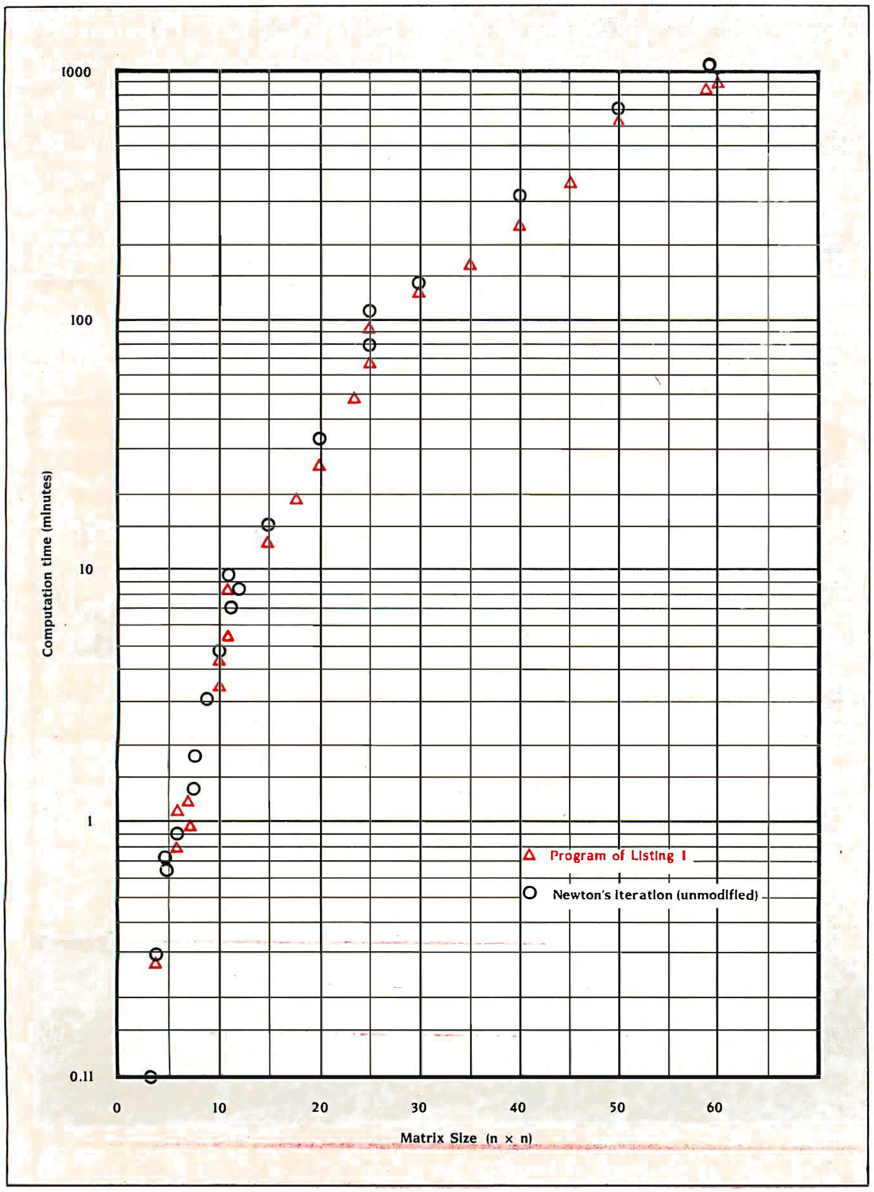


Figure 3: *A plot of log (computation time) versus matrix size.*

430 is then entered.

The first part of this iteration, lines 290 through 360, updates the error matrix according to step 4 of our algorithm (figure 2) and provides some tests for escape from the loop. Line 320 prints out to the screen, during each loop, information regarding (1) the iteration number, (2) the values of the error matrix at two arbitrary positions, corresponding to the upper left and upper right elements, and (3) the values of the *B* matrix (approximate inverse of *A*) at the same two positions. Thus one can monitor the convergence process by arbitary sampling of the error and inverse matrices.

At line 380 the diagonal matrix *Q* of equation 13 is expressed as an "equivalent" (in information content) row matrix or "list," *X*(1,*I*). (Use of the *X* matrix for temporary storage, as we noted, avoids having to dimension another large array.) Each entry of this list multiplies all entries of the corresponding row of the error matrix at line 390. At the same line a 1 is added to each diagonal element, in accordance with equation 11, and the result is loaded back into the *E* matrix, to make maximum use of the available storage arrays. At the next two lines the matrix product on the right side of equation 11 is evaluated and loaded into the temporary storage matrix *X*, as discussed above. At line 420 the *X* matrix information is loaded back into the *B* matrix (representing B_h in equation 11) and the calculation loops back to line 280 to reiterate.

The remaining lines of the program, following escape from the loop, turn off the clock and display results. Line 470 offers the user the option of an additional separately timed iteration to confirm the stability of convergence. The program checks for convergence by examining the maximum error in *BA*. As an independent check on the approximation of the inverse, the program calculates the error in multiplying *AB* in lines 480 through 610.

Readers familiar with other BASICs should have no difficulty translating the Microsoft BASIC dialect of listing 1 for use with their own machines. When I invert a 60 by 60 matrix on my computer, the working time is the better part of a day, so it is desirable to have no other uses planned for the computer. Observed times required by the T300 for inverting random-entry matrices of various sizes by the program of listing 1 are shown in the semilogarithmic plot of figure 3. Of course, the time depends somewhat on the error criterion (*DI* value) selected, but this generally alters the required number of iterations *H* by

(continued)

Listing 1: A BASIC *program for the modified* Pan-Reif *matrix-inversion method.*

```
10 REM Real-entry matrix inversion (Pan-Reif method)
20 REM Program by Thomas E. Phipps, Jr.
30 REM Ref= Proc. 17th Annual ACM Sympos. on Theory
40 REM of Computing, Providence, RI, May 1985
50 REM Random-entry matrices, single precision
60 REM Quartic modification of Newton's iteration
70 INPUT "Run number = ";RN
80 REM N data is in line 640, D1 data in line 660
90 READ N, D1:RANDOMIZE RN:OPTION BASE 1
100 REM Can optionally insert DEFDBL A,B,E,X here
110 REM A is the matrix to invert, B is the
        approximate inverse of A, E is the error
        matrix for the inverse, and X is a temporary
        storage matrix as explained in the article.
120 DIM A(N,N),B(N,N),E(N,N),X(N,N)
130 REM Generate random-entry A matrix. For real
        data, replace 140 by an INPUT statement
        and input normalized data (each element
        of A is divided by the largest element, L).
        Delete line 150. B and D1 must be
        multiplied by L to find the inverse and error
140 FOR I=1 TO N:FOR J=1 TO N:A(I,J)=RND(1):NEXT:NEXT
150 FOR I=1 TO N:FOR J=1 TO N:IF RND(1)<.5 THEN
                                  A(I,J)=-A(I,J)
160 NEXT :NEXT
170 CLS:TIME$="00"    'Start clock
180 REM Eval. t by Pan-Reif eq 8 in BYTE article
190 FOR I=1 TO N:R0=0:S0=0:FOR J=1 TO N
200 R0=R0+ABS(A(I,J)):S0=S0+ABS(A(J,I)):NEXT J
210 X(1,I)=R0:E(1,I)=S0:NEXT I:T1=0:T2=0
220 FOR I=1 TO N:IF X(1,I)>T1 THEN T1=X(1,I)
230 IF E(1,I)>T2 THEN T2=E(1,I)
240 NEXT I:T=1/(T1*T2)
250 REM Eval. initial B-matrix
260 FOR I=1 TO N:FOR J=1 TO N:B(I,J)=T*A(J,I):NEXT:
                                   NEXT :H=0
270 PRINT "ITER."TAB(10);"E(1,1)"TAB(28);"E(1,N)"
    TAB(46);"B(1,1)"TAB(64);"B(1,N)"
280 REM Eval. error matrix E
290 FOR I=1 TO N:FOR K=1 TO N:Z=0:FOR J=1 TO N
300 Z=Z+B(I,J)*A(J,K):NEXT J:E(I,K)=-Z:NEXT K:
                                    NEXT I
310 FOR I=1 TO N:E(I,I)=1+E(I,I):NEXT I
320 BEEP:PRINT H;TAB(6);E(1,1);TAB(24);E(1,N);
            TAB(42);B(1,1);TAB(60);B(1,N)
330 IF H>50 THEN PRINT "STUCK!":BEEP:BEEP:
                                 GOTO 620
340 REM Test for escape from loop
350 FOR I=1 TO N:FOR J=1 TO N:IF ABS(E(I,J))>D1
                                THEN 370
360 NEXT :NEXT :GOTO 440
370 H=H+1   'Newton's iteration
                 (quartic modification)
380 FOR I=1 TO N:
    X(1,I)=1+(1+(1+(1+E(I,I))*E(I,I))*E(I,I))*E(I,I):
    NEXT
390 FOR I=1 TO N:FOR J=1 TO N:E(I,J)=X(1,I)*E(I,J):
                      NEXT :E(I,I)=1+E(I,I):NEXT
400 FOR I=1 TO N:FOR K=1 TO N:W=0:FOR J=1 TO N
410 W=W+E(I,J)*B(J,K):NEXT J:X(I,K)=W:NEXT K:NEXT I
420 FOR I=1 TO N:FOR J=1 TO N:B(I,J)=X(I,J):NEXT:
                                       NEXT
430 GOTO 280
440 REM output follows
```

(continued)

It is great fun to watch the process of inverting a 10 by 10 matrix on the screen.

only 1 or 2. Typical values of *H* for reasonable convergence (four to five figures of accuracy of *B*-matrix elements) are 10 to 17 iterations for small (say, 10 by 10) matrices and 21 to 27 iterations for matrices of 30 by 30 and up. The corresponding clock times are roughly four minutes and two hours. The inversion times and iteration numbers vary, as explained below, with the "condition" of the matrix to be inverted.

It is great fun, and instructive, to watch the process of inverting, say, a 10 by 10 matrix evolve on the video screen. The calculation prints out iterations at a pace that is easy to follow (17-second intervals). Typically, there is a steady decrease of the on-diagonal elements of the error matrix, as shown by the sample element *E*(1,1), starting from around 0.95, as given by the Pan-Reif procedure for evaluating B_0. The off-diagonal elements, as typified by *E*(1,*n*), start small and rise, say, to around 0.1 to 0.3. Then, for iteration numbers around 5 to 10 or more, there is a period of "struggle," during which the error bounds do not decrease very much, but the *B*-matrix values, which have been small, begin to change fairly rapidly in sign and magnitude. As this phase comes to an end, the next few iterations produce rapid, systematic changes in the *B-matrix* entries and dramatic decreases in the error bounds both on and off diagonal as the iteration gets itself sorted out and homes in on its target.

Finally, if you have set too stringent an error bound *D*1 (see line 350 in listing 1), there will be an ultimate phase of aimless "hunting" in which typical error magnitudes are small, of the order of 10^{-7}, and in which only

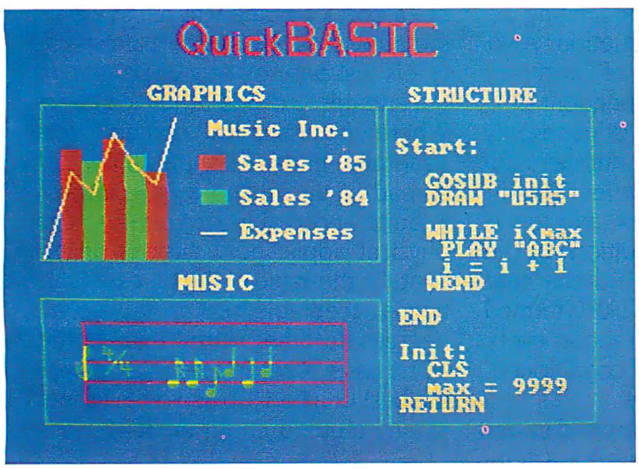
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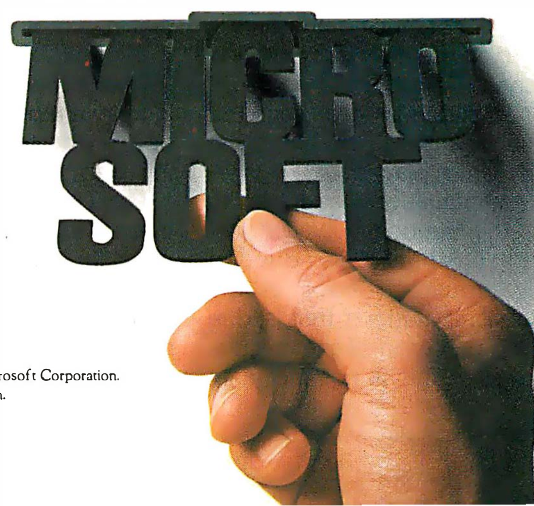
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```
450 T$=TIME$:BEEP:BEEP:BEEP:PRINT "Run number";RN,
                                  "Duration = ";T$
460 PRINT "No. iter.=";H,"Matrix dim.="N,
                              "Max. error=";D1
470 INPUT "Another iteration (y,n)";C$:
     IF C$="Y" OR C$="y" THEN TIME$="00":GOTO 370
480 PRINT "The maximum error was calculated by
          multiplying A^-1*A."
490 PRINT "As a check on the true error in the
          approximated inverse matrix"
500 PRINT "the maximum error in A*A^-1 will now
          be determined."
510 ERASE X       'recycle the temporary storage
                   matrix for errors in A*A^-1
520 DIM X(N,N)
530 FOR I=1 TO N:FOR J=1 TO N:FOR K=1 TO N
540 X(I,K)=X(I,K)+A(I,J)*B(J,K)
550 NEXT :NEXT :NEXT
560 REM You may print out the matrix and its
        inverse by placing a PRINT command for
        A and B in the following loop.
570 FOR I=1 TO N:FOR J=1 TO N
580 TEST.VAL=ABS(X(I,J)):IF I=J THEN
                     TEST.VAL=ABS(1-TEST.VAL)
590 IF TEST.VAL>MAX.ERROR THEN MAX.ERROR=TEST.VAL
600 NEXT :NEXT
610 PRINT "The max. error found this way is ";
                                    MAX.ERROR
620 END
630 REM Matrix dim. N =
640 DATA 10
650 REM Error criterion D1 =
660 DATA 3E-6
```

the least significant two or three decimal places of the *B*-matrix entries change. This would go on forever (if not stopped at 50 iterations by line 330 of the program), so one must press the Break key and either try again with a larger *D*1 value or record the *B*-matrix results, which will probably be good to four significant figures. (The listing I program does not provide for printing out any of the matrices, so these remain invisible to the user, but the user who wants to see A and B can add a few steps to the program or command printouts in the "direct" mode after computation has stopped.) The calculation never becomes unstable or divergent but just "bounces around" continually in the last decimal places.

The first explanation that comes to mind for the hunting behavior just described is that it is due to cumulative round-off error in the numerous computations, that is, due to the finite precision of the calculations. However, this is not the main story, since I have tried the same thing in double precision with no noticeable improvement in the limiting accuracy of *B*-matrix evaluation. Also, that attainable level of accuracy seems to be fairly independent of *n*, the matrix size, and to depend only on the particular set of numbers appearing as *A*-matrix entries. Clearly, another factor is at work, and this is what is called the "condition" of the *A* matrix. Any matrix sufficiently near to being singular or zero-like is termed "ill conditioned." In a sense every matrix is more or less ill conditioned. It is a matter of degree.

That is, the bouncing around under indefinite repetition of Newton's iteration, producing an uncertainty affecting the *K*th and higher places of accuracy (significance) of the computed inverse matrix, will occur for *some K* value for any *A* matrix. Usually *K* is greater than 4 or 5 and may be greater than the number of decimal places specifying the precision of our calculation. In that case we call the *A*

In a sense every matrix is more or less ill conditioned. It is a matter of degree.

matrix "well conditioned" and may not be able to detect the bouncing around at all. But occasionally we encounter a nearly zero-like matrix for which *K* is small, the uncertainty of our answer is great, and the entries of the inverse matrix become very sensitive to the precise numerical values of the entries of the *A* matrix. This is the ill-conditioned case, typified by numerically large entries of the inverse matrix.

The quantity *K*, which can be evaluated from the "long run" statistics of Newton's iteration, can in fact be used to quantify the "condition" of a matrix. (The larger *K*, the better the condition of the *A* matrix.) An ill-conditioned matrix cannot normally be spotted by prior inspection; so the problem is an insidious one. But the uncertainty we are speaking of—a sort of numerical analogue of the physicist's "Heisenberg uncertainty"—is just nature's way of penalizing the attempt to divide by (almost) zero. Where it arises in practice one generally finds that an enhanced spread of uncertainty of the answer is quite acceptable (for purposes of physical application), just as uncertainty in the value of the tangent function is acceptable near an angle of 90 degrees. In other words, even in the worst case, Newton's iteration makes the best of a bad job and does as well as any method could do. ■

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THE RUNGE-KUTTA METHODS

BY BENKU THOMAS

Approximating solutions to ODEs

A DIFFERENTIAL EQUATION is the mathematical relationship between an unknown function of one or more variables and one or more of its derivatives. In solving the differential equation, we obtain an expression for the function so that we may predict its value at any point.

If we are able to obtain an exact expression for the solution to a differential equation, we say we have obtained an analytical, or true, solution to the differential equation. It is possible to obtain analytical solutions to some differential equations. However, most of the time the equations are difficult to solve analytically, and sometimes they are just plain impossible. So we resort to numerical solutions that attempt to give a numerical value (an approximation) of the unknown function for any combination of values of the variables in the function.

DIFFERENTIAL EQUATIONS

Differential equations may be classified into different types, each requiring different numerical methods for their solution. If the equation involves derivatives of a function having only one independent variable (that is, only derivatives with respect to the one independent variable are involved), then it is an *ordinary differential equation* (ODE). If more than one independent variable is involved, then we have a *partial differential equation* (PDE). ODEs may be further classified by the type of additional information we have about them. If information (such as the value of the function we are solving for) is known at a particular value of the independent variable, the ODE is an *initial value problem* (IVP). However, if information about the function or its derivatives are known at two different values of the independent variable—the boundaries of the problem—we have a *boundary value problem* (BVP). Differential equations describing changes in time are almost always IVPs, since information about the problem is known at zero time (the initial value). On the other hand, steady-state heat-conduction problems are often BVPs, since information is known at the boundaries of the space in which conduction is taking place. The methods I will discuss in this article will solve only IVPs, but this subject is sufficiently involved that L. F. Shampine and M. K. Gordon have written an entire book about it (see reference 1).

ERROR CONTROL

There are a number of problems with any numerical technique, but the one common to all differential equation solvers is error control. The errors in the solutions arise from a couple of sources. First, because all numerical solutions are necessarily approximations of the true solutions, there is always an error (however small it may be) associated with any numerical answer. This is the *global error*, and it is a measure of the difference between the true solution and the numerical one. We usually use some sort of series approximation of the unknown function and make a prediction of the next value of the function u_{i+1} based on the value u_i that we have

(continued)

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already estimated. However, u_i is itself a numerically predicted value, and it will be in error to some degree when compared to the true solution. The error in predicting u_{i+1}, caused by our (incorrect) assumption that u_i contained no error, is called the *local (truncation) error* in u_{i+1}. As shown in figure 1, the global error contains two components—the local error and a *propagation error* that results from the propagation of the global error from the previous step. The local error, although a subset of the global error, can actually be estimated, so it is used to keep a check on the global error.

Second, any numerical method, however good, must execute in a machine environment, which means it must work with finite precision arithmetic. So, in addition to the global errors, we will also have *round-off errors*. A good numerical method must be able to minimize all errors and inform the user of the magnitude of error to be expected. (For an excellent introduction to the effects of round-off errors on numerical solutions, see chapter one in reference 2.) You can minimize the effect of round-off error by working in the highest precision possible. In FORTRAN this means using double-precision variables for *all* real numbers.

THEORY

From our definition of the IVP, we can write a general equation for any IVP as shown in figure 2.1. Here we use the notation that $y^{(i)}$ represents the ith differential of y with respect to x (i.e., d^iy/dx^i). Equation 2.1 in figure 2 is an mth-order equation, since it involves an mth differential of y. It would be difficult to write a numerical solver that would be able to deal with any IVP of any order, so we must find a way of transforming the mth-order IVP into a series of first-order IVPs. Let's do this by way of an example from elementary college physics—simple harmonic motion. [*Editor's note: David Leo's text box on page 196 presents a* BASIC *fourth-order Runge-Kutta routine for solving this problem with damping. Setting* C *to* 0 *yields the undamped problem.*] Suppose we have an undamped spring-mass system in which a mass of 10 pounds, when attached to the end of a steel spring, causes it to stretch by 2 inches. We would like to know how the mass would move if the spring were stretched by an additional 2 inches and then released. The spring constant is 60 lb/ft and the weight of the mass is 10/32 lb/(ft/sec²). The equation of motion for this system (as presented in reference 3) is: $y'' = -(32/10)60y$ (y is distance in feet) with the initial conditions $y(0) = 1/6$ ft and $y'(0) = 0$ ft/sec.

To transform this second-order differential equation into a system of first-order IVPs, let's introduce two new variables defined as $w_1 = y$ and $w_2 = y'$. Then we can write $w_1' = y'$ and $w_2' = y'' = -(32/10)60y$. So we now have a system of two first-order IVPs with the new initial conditions $w_1(0) = 1/6$ ft and $w_2(0) = 0$ ft/sec. In this manner, we may reduce a general mth-order IVP into a system of m first-order IVPs. In that case we would introduce the new set of variables—$w_1=y$, $w_2=y'$, . . . , $w_m=y^{(m-1)}$. For convenience, we can write such a system of IVPs using standard vector notation as $\mathbf{y}' = \mathbf{f}(x, \mathbf{y})$, with initial conditions $\mathbf{y}(x_0) = \mathbf{y}_0$.

To be completely general, any method we devise must be capable of solving a system of initial-value ordinary differential equations. We state the general IVP as $y'=f(x,y)$ with $y(x_0)=y_0$. Our numerical solution must approximate the true solution, so a good starting point in developing a method is to assume that we may use some sort of series approximation (such as a Taylor series) of the true solution. Suppose we know that the exact solution at x_i is $y(x_i)$ and x_{i+1} is a point close to x_i. Then a Taylor series expansion for $y(x_{i+1})$ about x_i is as shown in equation 2.2a. If we choose a point z, such that $x_i < z < x_{i+1}$, we obtain the equation 2.2b. But from our statement of the initial-value problem, we have an expression for y'. Substituting this into the Taylor expansion we get equation 2.2c, where we have defined $(x_{i+1}-x_i)$ as h, our step size. Also, if the limits of the interval over which we are interested in solving the problem are A and B, $A+N\times h = B$. Suppose the value of $y(x_i) \cong u_i$. Then, if we substitute this for $y(x_i)$ and truncate the series after the second term,

(continued)

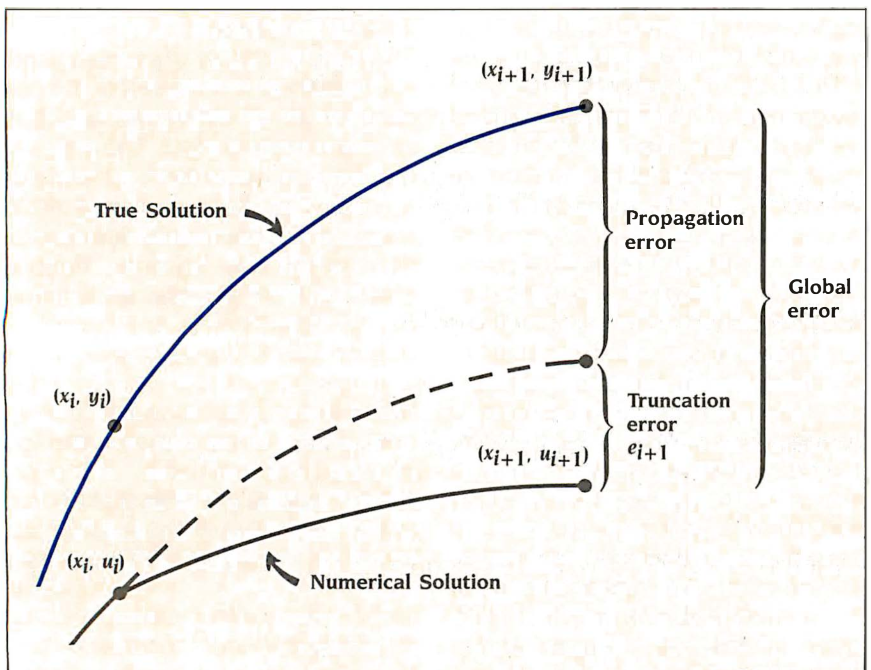


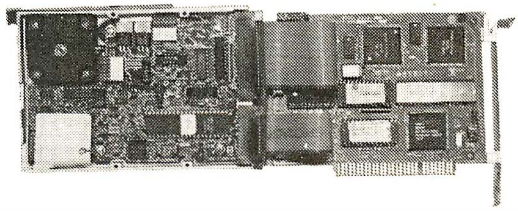
Figure 1: *An illustration of errors in a numerical solution.*

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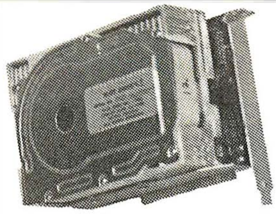
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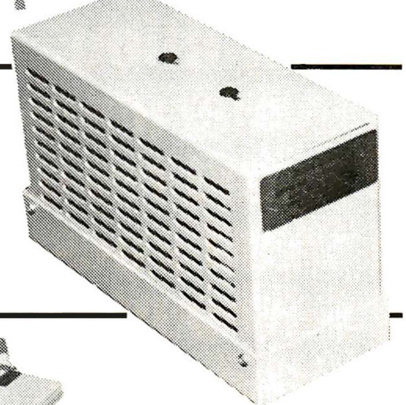
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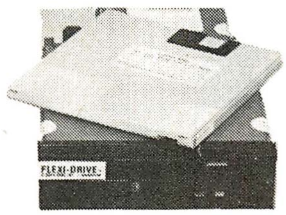


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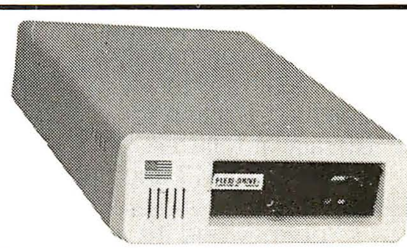
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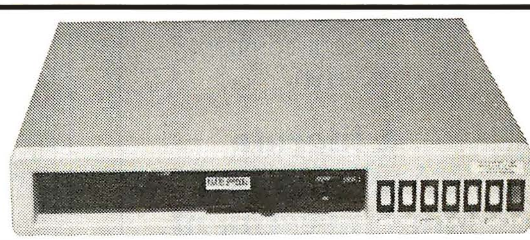
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(2.1) $$y^{(m)} = f(x,y,y^{(1)}, y^{(2)}, \ldots, y^{(m-1)})$$

with the initial conditions:

$$y(x_0) = y_0$$
$$y^{(1)}(x_0) = y_0^{(1)}$$
.
.
$$y^{(m-1)}(x_0) = y_0^{(m-1)}$$

(2.2a) $$y(x_{i+1}) = y(x_i) + (x_{i+1}-x_i)\, y'(x_i) + \frac{(x_{i+1}-x_i)}{2!}\, y''(x_i) + \ldots + \frac{(x_{i+1}-x_i)^k}{k!}\, y^{(k)}(x_i)$$

(2.2b) $$y(x_{i+1}) = y(x_i) + (x_{i+1}-x_i)y'(x_i) + \frac{(x_{i+1}-x_i)}{2!}\, y''(z)$$

(2.2c) $$y(x_{i+1}) = y(x_i) + hf(x_i,y(x_i)) + \frac{h^2}{2!} f'(z,y(z))$$

(2.2d) $$u_{i+1} = u_i + hf(x_i, u_i) \quad i=0,1,2,\ldots,N-1$$

(2.3) $$u_{i+1} = u_i + h \sum_{j=1}^{q} a_j k_j$$

$$x_{n+1} = x_n + h$$

where

$$k_j = f(x_i + c_j h;\ u_i + h \sum_{m=1}^{j-1} b_{jm} k_{m})$$

$$C_1 = 0$$

(2.4a) $$\frac{df_i}{dx} = \frac{\delta f_i}{\delta x} + \frac{\delta f_i}{\delta y}\frac{dy}{dx}\Bigg|_{x=x_i} = (f_x + f_y f)_i$$

(2.4b) $$u_{i+1} = u_i + hf_i + \frac{h^2}{2!}(f_x + f_y f)_i + O(h^3)$$

(2.4c) $$u_{i+1} = u_i + a_1 h f_i + a_2 h f_i + a_2 h^2 c_2 (f_x)_i + b_{21} a_2 h^2 (f_y f)_i$$

(2.4d) $$a_1 + a_2 = 1.0$$
$$a_2 c_2 = 0.5$$
$$a_2 b_{21} = 0.5$$

(2.5) $$u_{i+1} = u_i + h \sum_{j=1}^{4} a_j k_j$$

$$k_j = f(x_i + c_j h,\ u_i + h \sum_{m=1}^{j-1} b_{jm} k_m)$$

(2.6a) $$u_{i+1} = u_i + h \sum_{j=1}^{5} a_j k_j$$

$$u_{i+1}^* = u_i + h \sum_{j=1}^{6} a_j k_j$$

(2.6b) $$e_{i+1} = h \sum_{j=1}^{6} e_j k_j$$

(2.7) $$y_1 = \frac{1000}{1001} e^{-1001t} + \frac{1}{1001} e^{-t}$$

$$y_2 = \frac{-1000}{1001} e^{-1001t} + \frac{1000}{1001} e^{-t} \quad (t = \text{time})$$

(2.8) $$k_j = f(x_i + c_j h,\ u_i + h \sum_{m=1}^{j} b_{jm} k_m)$$

Figure 2: *Equations used in this article.*

we get equation 2.2d, with the initial condition that $u_0 = y_0$. This is the Euler method and is the simplest approximation formula. Because of our truncation of the Taylor series after the second term, we neglected the second-order term in $y''(z)$. Since this term contains h^2, we say that the local truncation error at x_{i+1} will be $e_{i+1} = O(h^2)$, where $O(\,)$ means *terms of the order of*. If the exact solution at x_{i+1} were $y(x_{i+1})$, the global error G at x_{i+1} would be $G_{i+1} = y(x_{i+1}) - u_{i+1}$. A method is pth order (accurate) if $e_{i+1} = O(h^{(p+1)})$.

So, the Euler method is a first-order method. Since the local truncation error is proportional to the step size to power of $p+1$, decreasing the step size will reduce the magnitude of this error, and the degree of reduction will be larger the higher the order of the method we use.

RUNGE-KUTTA ALGORITHMS

Runge-Kutta methods are a class of algorithms that involve the evaluation of the differential function at points between x_i and x_{i+1}. The general form of the algorithm is shown in equations 2.3. Notice that we can obtain the Euler formula from this algorithm simply by letting $q=1$ and $a(1)=1$, so that $k(1) = hf(x_i,u_i)$. The Euler method is therefore the lowest-order Runge-Kutta method.

For higher-order schemes, the parameters a, b, and c need to be evaluated. To do this, we compare the Runge-Kutta formula with the Taylor expansion of equivalent order and obtain the parameters by comparing coefficients of like terms. To show how this is done, let's develop a Runge-Kutta method for $q=2$. In this case, we would want to include the second-order term in the Taylor expansion. In addition, if we were to write $f'(x_i,y(x_i))$ as shown in equation 2.4a, then the Taylor expansion we require could be written as shown in equation 2.4b, where $O(h^3)$ are the terms we will truncate. Next, we write the expansions for the k's about x_i: $k_1 = hf(x_i,u_i) = hf_i$ and $k_2 = hf(x_i+c_2h,\ u_i+b_{21}k_1)$. By using a mean-value point Taylor series expansion in two variables for k_2, we get $k_2 = hf_1 + h^2(c_2f_x + b_{21}f_yf)_i$. Using these expressions for the k's in the equation for u_{i+1}, we obtain equation 2.4c. By comparing the like powers of h from this expression and from the Taylor expansion, equations 2.4d result.

There are three equations and four unknowns, so we are free to choose one of them. Of course, a different second-order scheme will result from each choice of the free parameter. If we decide to choose the value of c_2 to be 0.5, the Runge-Kutta algorithm is $u_{i+1} = u_i + hf(x_i+0.5h,\ u_i+0.5hf_i)$. Or, if we choose $c_2=1$, $u_{i+1} = u_i + 0.5h[f_i+f(x_i+h,\ u_i+hf_i)]$. For both equations, $i=0,1,\ldots,N-1$ and $u_0=y_0$.

In this manner, it is possible to develop Runge-Kutta methods of any order by choosing an appropriate value for q. Table 1 shows the value for q for the order p that we choose. Note that from the form of the Runge-Kutta algorithm we will have to evaluate the differential function q times, so although we drastically reduce our error for a given step size by using a higher-order method, we do so at the expense of increased function evaluations.

RKG-4

The Runge-Kutta-Gill (RKG-4) scheme is an example of a fourth-order method. Rather than write out the equations in full as I did for the second-order methods, it is more convenient to write out the equations using a "summation" format and put the constants in a table. This is particularly useful when coding the algorithm because the constants may be put in arrays and the algorithm evaluated in a loop. The RKG-4 method is shown in summation format in equations 2.5; the constants are given in table 2.

Remember that one of the demands we make on any method we develop is for it to be able to give us an estimate of the magnitude of the error. Even if we intend to obtain a method that will control the error to within set limits, we need to have a method to evaluate the error. Of course, any scheme based on a knowledge of the form of the analytical solution is out of the question. An estimate of u_{i+1} using a step size of $h/2$ would be more accurate than one based on a step size of h. If the estimate based on $h/2$ is u^*_{i+1}, then an estimate of the error would

(continued)

be: $e_{i+1} = u^*_{i+1} - u_{i+1}$. This would certainly work but would not be very efficient. Table 3 shows why this is so. The number of function evaluations per step is quite high with this scheme. For example, the RKG-4 method that required only 4 function evaluations per step now requires 11 to estimate the error.

RKF-4

A more efficient method is the Runge-Kutta-Fehlberg fourth-order (RKF-4) scheme (see reference 4), which uses a higher-order formula to estimate u^*_{i+1} than the one used to compute u_{i+1}. Using the generalized summation format, the RKF-4 formulas are written as shown in equations 2.6a, with the usual equation for k_j and using the constants given in table 4. Now we have two vectors, a and a*, for the evaluation of u_{i+1} and u^*_{i+1}, respectively. Also, there is an additional vector, **e**, that contains the constants used in evaluating the error term and is the vector resulting from the subtraction of a from a*. Therefore, u^*_{i+1} never actually needs to be evaluated; the error is obtained directly from equation 2.6b.

The interesting point about this scheme is that, although five function evaluations are required for a fourth-order accurate u_{i+1}, only a total of six function evaluations are required for u_{i+1} and the error estimate since the k's need to be evaluated only once (unlike in the half-step-size error-estimation method). The Fehlberg method's forte is the significant reduction in function evaluations required to estimate the error.

RKV

The Fehlberg technique may be extended to higher-order methods by suitable choice of parameters in the Runge-Kutta algorithm. J. H. Verner (see reference 5) has developed a number of schemes based on this technique. Constants for fifth- and seventh-order methods are given in tables 5 and 6 (RKV-5 and RKV-7), respectively. If you use the Fehlberg fourth-order method to evaluate a quadrature, it will fail because the error estimate will always be zero. The Verner methods avoid this problem.

Armed with this theoretical information, we are now in a position to develop a working algorithm and code to solve a system of initial-value ordinary differential equations.

Development of a Working Algorithm

[*Editor's note*: Mr. *Thomas has provided* FORTRAN *source code for a fourth-order Fehlberg method and fifth- and seventh-order Verner method Runge-Kutta subroutines, complete with documentation. In addition, he has provided three applications calling routines: One solves the radioactivity problem discussed later, the second involves temperature versus rate of reaction in a chemical reactor, and the third calculates the orbit of a satellite. All examples are discussed in a text file included on disk. Not only do the sample calling routines demonstrate the proper form for such routines, they are of interest in their own right. The programs are available on disk as explained in Disks and Downloads on page 346, for downloading via modem from* BYTEnet *Listings at* (617) 861-9764, *or in hard copy by writing* BYTE, POB 372, *Hancock,* NH 03449.]

Usually, we will want to obtain numerical values for the solution at a number of (normally equispaced) values of the independent variable. For example, if we are interested in the region from x=0 to x=1, we might want to know intermediate values at x=0.1, x=0.2, and so on, right up to x=1. We could do this by repeated calls to the solver. Starting at, say, x=0, we predict a value at x=0.1, then use this as a new starting point for the interval from x=0.1 to x=0.2. However, we need to evaluate the constants in the Runge-Kutta algorithm only once so long as we do not change the order of the method we are using. Therefore, the first thing we do on the initial call to the solver is evaluate the constants. This simply involves evaluating the fractions that are given in tables 4, 5, or 6 and assigning them to the appropriate variables. It is necessary to prevent reevaluation of the constants on each sucessive call to the solver, unless the order of the

(continued)

Response of a System to Complex Driving Forces

BY DAVID M. LEO

The vibration of a nonlinear spring-mass-damper system is most often calculated by numerical integration on a digital computer. I originally wrote the Onebody program (listing A) to calculate the motion of a linear spring-mass-damper system due to complex driving forces, although it may be used to show the effects of nonlinear spring and damper reaction forces as well. The program is written in terms of arrays, so it is easy to model larger systems (more masses) with relatively minor modifications.

I analyzed the system shown in figure A with the program. The spring constant is nonlinear, as it increases rapidly beyond a certain displacement. The Coulomb damping force has constant magnitude, but always opposes the velocity. The driving force $F(t)$ may be any function of time that you can specify in BASIC. Certain discontinuous forces, however, require experience in manipulating the integration time step to avoid numerical instabilities.

To perform the calculation, the program simulates an analog model of the system, also shown in figure A. The integrators shown in the model are simulated on the digital computer by a fourth-order Runge-Kutta algorithm. The output is written to a file, OUT.DAT, in the form: Driving force, velocity, displacement, driving force, velocity, displacement, etc. Plotting the data must be done with a separate routine that would use OUT.DAT for data.

Figures B and C show the displacement, $X(2)$, and the driving force, $FNX(T)$, as functions of time for two simple cases. The remark statements in the program should guide you in making modifications for other cases of interest.

David M. Leo *(c/o* BYTE, *70 Main St., Peterborough,* NH 03458) *is senior engineer for a large turbine manufacturer. His area of specialization is vibrations and stress in turbomachinery.*

Listing A: *The fourth-order Runge-Kutta* BASIC *program used by the author to produce the data for figures* B *and* C. *With the default values, the program's run time is about* 5 *minutes on an* IBM PC.

```
10 REM N = THE NUMBER OF INTEGRATORS
20 REM V(I) = INTEGRATOR INPUTS
30 REM X(I) = INTEGRATOR OUTPUTS
40 REM X(1) = VELOCITY; X(2) = DISPLACEMENT
50 REM C = THE DAMPING CONSTANT
60 REM M = MASS; K = SPRING CONSTANT
70 REM TMIN = TIME AT WHICH PRINTING TO OUTPUT
       FILE BEGINS
80 REM TMAX = TIME AT WHICH PRINTOUT ENDS
90 REM DT = TIME STEP SIZE
100 REM ********************************
110 OPEN"OUT.DAT" FOR OUTPUT AS #1
120 N=2:C=1500:M=2:K=100000!
130 DIM X(N),K1(N),K2(N),K3(N),K4(N),DUM(N),V(N)
140 DT=.0001:TMIN=DT:TMAX=500*DT
150 REM FNX(T) IS THE DRIVING FORCE
160 DEF FNX(T)=5000*(SIN(200*T))^5
170 REM NEXT ARE THE INITIAL CONDITIONS ON
        VELOCITY,X(1),AND DISPLACEMENT X(2)
180 X(1)=.001:X(2)=.001
190 REM NEXT IS THE EQUATION FOR THE INPUT TO
        INTEGRATOR #1
200 REM IN THIS CASE, THERE IS COULOMB DAMPING
210 V(1)=(FNX(T)-K*X(2)-C*SGN(X(1)))/M:V(2)=X(1)
220 REM NEXT ARE THE STEPS IN THE INTEGRATION
        ACROSS ONE TIME STEP
230 COUNT=COUNT+1:IF COUNT=2 THEN 260:IF COUNT=3
           THEN 270:IF COUNT=4 THEN 280
240 FOR I= 1 TO N:K1(I)=DT*V(I):NEXT I
250 T=T+DT/2:FOR I=1 TO N:DUM(I)=X(I):
    X(I)=DUM(I)+K1(I)/2:NEXT I:IF COUNT=1 THEN 210
260 FOR I= 1 TO N:K2(I)=DT*V(I):
    X(I)=DUM(I)+K2(I)/2:NEXT I:IF COUNT=2 THEN 210
270 FOR I=1 TO N:K3(I)=DT*V(I):X(I)=DUM(I)+K3(I):
          NEXT I:T=T+DT/2:IF COUNT=3 THEN 210
280 FOR I=1 TO N:K4(I)=DT*V(I):
     X(I)=DUM(I)+(K1(I)+K4(I))/6+(K2(I)+K3(I))/3:
    NEXT I
290 REM NEXT STEPS APPROXIMATE STATIC/DYNAMIC
        FRICTION
300 IF ABS(X(1))>.5 THEN 330
310 C=3000
320 GOTO 340
330 C=1500
340 IF X(2)>1! THEN 440
350 REM FROM RUNNING THIS A FEW TIMES, WE EXPECT
        ABS(DISPLACEMENT) < .030
360 REM OVER THIS RANGE, THE NONLINEAR SPRING
        RATE CAN BE APPROXIMATED AS FOLLOWS:
370 K=100000!+300000!*(SIN(50*X(2)))^4
380 IF T<TMIN THEN 210
390 PRINT #1,FNX(T):FOR I=1 TO N:PRINT #1,X(I):
                                     NEXT I
400 IF T>TMAX THEN 420
410 GOTO 210
420 CLOSE
430 GOTO 450
440 PRINT" DIVERGENT OSCILLATION ENCOUNTERED"
450 END
```

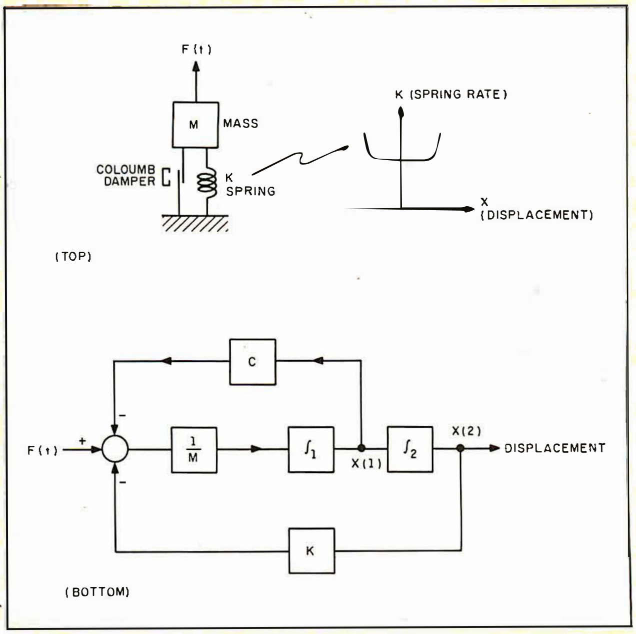


Figure A: *The top of this figure shows a mechanical model of a damped spring-mass system. The bottom shows a block diagram of an analog model equivalent to the mechanical model.*

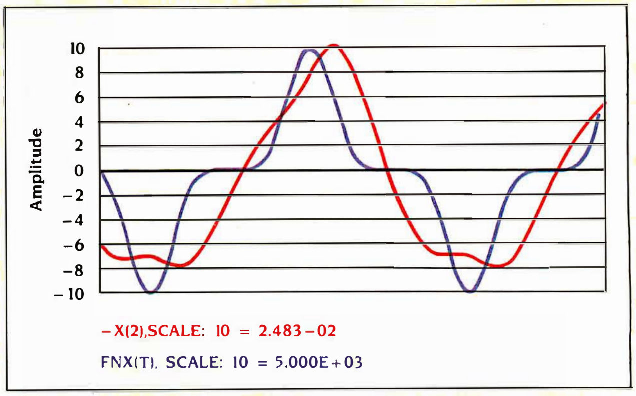


Figure B: A *graph of displacement* (X(2)) *and driving force* (FNX(T)) *versus time for the startup of the system with* Coulomb *damping.*

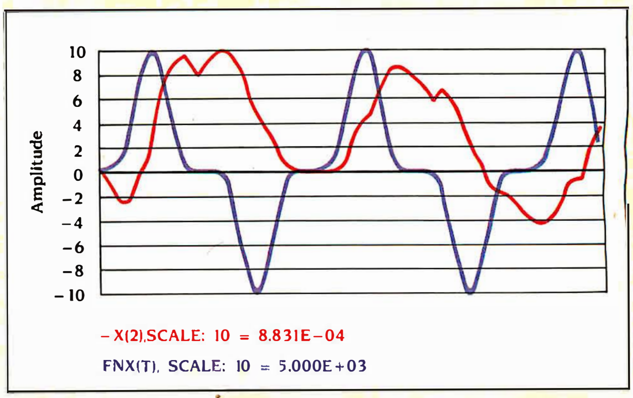


Figure C: A *graph of displacement* (X(2)) *and driving force* (FNX(T)) *versus time for a system with* Coulomb *damping and nonlinear spring force.*

method is being changed.

Since the Fehlberg/Verner schemes use a higher-order method to estimate u^*_{i+1}, we can cheat a little and use the value for u^*_{i+1} in place of u_{i+1}. This will give us a better estimate and now e_{i+1} will represent an upper bound on the error.

If we examine the vectors **a**, **a***, and **e** in tables 4, 5, and 6, we see that there are a number of zero elements in them. The number of zeros increases for the higher-order methods. Because of this, the most efficient way of predicting u_{i+1} is to evaluate the expressions for the k's in a loop and then evaluate the Runge-Kutta expression for u_{i+1} as one straight equation (i.e., not in a loop). When evaluating our constants, we will set $a1=a^*(1)$, $a2=a^*(2)$, and so on; $er1=e(1)$, $er2=e(2)$, and so on. The matrix **B** in the tables have no row 1, and to avoid having an entire row of zeros we store the elements in our working matrix **B** of size $j-1$ by $j-1$, so that $b_{work}(j-1,m) = b_{table}(j,m)$. The matrix **B** is lower triangular, so storage of this in a square matrix is not space-efficient. However, the extra space used is not enormous, and in FORTRAN we do not have much choice. For a system of NEQN equations, a procedure for predicting values of $\mathbf{u}_{i+1}$, using the RKF-4 method, given a value for $\mathbf{u}_i$ at x_i, and a step size h, would look something like that shown in listing 1.

For the Fehlberg method, q equals 6. Since the code for predicting $\mathbf{u}_{i+1}$ using any of the higher-order methods is the same other than the expressions for $\mathbf{u}_{i+1}$ and $\mathbf{e}_{i+1}$, the listing 1 code could be modified to include those expressions. In that case, q would be passed in as an input parameter as well as an integer, say IMETH, which would select the order.

Table 1: *The minimum value for q in the Runge-Kutta summation equations for a given order p.*

p	2	3	4	5	6	...
q	2	3	4	6	8	...

Table 2: *The constants for the Runge-Kutta-Gill fourth-order method.*

j \ m	c	B(j,m) 1	2	3	4
1	0				
2	$\frac{1}{2}$	$\frac{1}{2}$			
3	$\frac{1}{2}$	$\frac{\sqrt{2}-1}{2}$	$\frac{2-\sqrt{2}}{2}$		
4	1	0	$\frac{-\sqrt{2}}{2}$	$\frac{2+\sqrt{2}}{2}$	
a(j)		$\frac{1}{6}$	$\frac{2-\sqrt{2}}{6}$	$\frac{1}{6}$	$\frac{2+\sqrt{2}}{6}$

Table 3: *The minumum number of function evaluations per step (f/step) required to obtain an error estimate using the half-step-size strategy for a given order p.*

p	2	3	4	5	6	...
f/step	2	3	4	6	8	...

STEP SIZE

The code also needs some way of controlling the errors. As we saw earlier, the error is a function of the step size, so one way would be to choose a very small step size for all problems. This is terribly inefficient, since some equations would only require a step size larger than any "safe" lower limit we might specify. Another problem would be that for a given step size, the nature of the differential equations would yield different magnitudes of error. In fact, the step-size requirements for a given differential equation may change over the interval we are interested in.

The best strategy for controlling the error would be to devise an algorithm that, given an error-tolerance limit (a limit on the error we would like to see), would continuously adjust the step size so that the error was kept within that limit. But how do we decide by how much to adjust the step size? One way would be to relate it to the error and keep changing the step size until we obtain an error below the tolerance limit.

It is possible to obtain a scheme based on some semitheoretical arguments. Suppose we have just made a step from (x_i,y_i) to $(x_{i+1},y_{i+1})_E$ with a step size of h, using a pth-order method. The error at this new point would be: $e_{i+1} = S(h^{(p+1)})$, where S = some function of step size.

If we specify an error-tolerance limit of TOL, there will be some optimum step size that would give us exactly this error had we taken a step of this size from (x_i,y_i) to a point $(x_{i+1},y_{i+1})_T$. This optimum step size will be a fraction or a multiple (ν) of the actual step size h that we used. It would be related to TOL by: TOL $= S(\nu h)^{(p+1)} =$

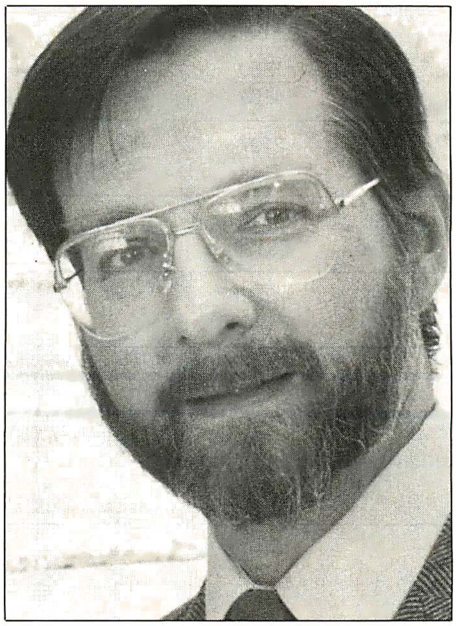
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Table 4: *The contstants for the Runge-Kutta-Fehlberg fourth-order method.*

j \ m	c	B(j,m) 1	2	3	4	5	6
1	0						
2	1/4	1/4					
3	3/8	3/32	9/32				
4	12/13	1932/2197	−7200/2197	7296/2197			
5	1	439/216	−8	3680/513	−845/4104		
6	1/2	−8/27	2	−3544/2565	1859/4104	−11/40	
a(j)		25/216	0	1408/2565	2197/4104	−1/5	
a*(j)		16/135	0	6656/12825	28561/56430	−9/50	2/55
e(j)		1/360	0	−128/4275	−2197/75240	1/50	2/55

Table 5: *The constants for the Runge-Kutta-Verner fifth-order method.*

j \ m	c	B(j,m) 1	2	3	4	5	6	7	8
1	0								
2	1/18	1/18							
3	1/6	−1/12	1/4						
4	2/9	−2/81	4/27	8/81					
5	2/3	40/33	−4/11	−56/11	54/11				
6	1	−369/73	72/73	5380/219	−12285/584	2695/1752			
7	8/9	−8716/891	656/297	39520/891	−416/11	52/27	0		
8	1	3015/256	−9/4	−4219/78	5985/128	−539/394	0	693/3328	
a(j)		3/80	0	4/25	243/1120	77/160	73/700		
a*(j)		57/640	0	−16/65	1337/2240	121/320	0	891/8320	2/35
e(j)		33/640	0	−132/325	891/2240	−33/320	−73/700	891/8329	2/35

$v^{(p+1)}S(h^{(p+1)}) = v^{(p+1)}e_{i+1}$. From this we get: $v = |TOL/e_{i+1}|^{(1/p+1)}$. This equation is from C. W. Gear (see reference 6). Using a slightly different argument, L. W. Johnson (see reference 7) shows that v is given by: $v = |TOL/e_{i+1}|^{(1/p)}$.

The factors affecting the choice between these two equations are discussed in the text file called Examples, included on disk. The v is a step-size adjustment factor that tells us (after the fact) what would have been the optimum step size to have used. If we stick to absolute values on TOL and e_{i+1}, then v is always positive. If v is greater than 1, then we know that we could have used a larger step size than the one we just used, so the error at $(x_{i+1},y_{i+1})_E$ is less than TOL. On the next step to (x_{i+2},y_{i+2}) we can hopefully use the larger step size. On the other hand, if v turns out to be less than 1, we know that we should use a smaller step size, and also that the error at $(x_{i+1},y_{i+1})_E$ will be greater than TOL. We will have to go back to (x_i,y_i) and try again with the reduced step size (vh). Since the error e_{i+1} is specific to the point $(x_{i+1},y_{i+1})_E$, there is no guarantee that using this reduced step size to reach the point $(x_{i+1},y_{i+1})_T$ will result in an error less than TOL. We can only recalculate v at this new point and keep repeating the process until we have made a successful step.

We now have the basis for developing a successful step-size strategy. But before we actually do so, we have to place some additional constraints on the algorithm to prevent a number of problems that may turn up. Most of these constraints have been developed over the years by researchers who have worked in this area of numerical analysis, and are based on semitheoretical arguments and a great deal of trial-and-error analyses.

Remember that we are adjusting our step size by the magnitude of the tuncation error, but are attempting to control the global error. Therefore, the common practice is to aim for a truncation error per unit step of TOL/2, in the hope that this will lead to a global error of the same order of magnitude as TOL (see reference 8). If we replace TOL by TOL/2 in the equation for v, we in effect scale v by $(1/2)^{(1/p+1)}$. Then the best step size to take is actually $s \times v \times h$, where s is the scaling factor on v. For a fourth-order method, s should be 0.871. The use of a scaling factor on v also has the effect of keeping down the number of rejections in the choice of step size. If the next step size h_{new} were defined by $h_{new}=vh_{old}$, it is likely that h_{new} would frequently be too large (since it is based on information at (x_{i+1},y_{i+1}), and this would mean repredicting the next value of y, (y_{i+2}), using a reduced step size. In this case, the scaling factor is also a safety margin on how much we allow the step size to grow. By trial-and-

(continued)

error it has been determined that the best formula for s (if it must also provide this restraint on v) is $(1/2)^{(1/p-1)}$. This gives a value of approximately 0.8 for the fourth-order method, which is in agreement with the value suggested by Johnson (see reference 7). The fifth- and seventh-order methods use values for s based on this formula of approximately 0.841 and 0.891, respectively.

To prevent the step size from swinging wildly from large to small and back to large, it is recommended (see reference 1) that $s \times v$ be constrained so that it is not less than 0.1 and not greater than v_{lim}. This may be likened to a damping factor on the step-size adjuster. For a fourth-order method, v_{lim} is $3/s$ ($\cong 3.78$) and is more conservative than the value of 5 suggested by Shampine and Gordon in reference 1. Values of $4/s$ and $5/s$ were found to work best for the fifth- and seventh-order methods, respectively.

In addition, if the step just taken (h_{old}) involved a reduction in the predicted step size, it is advisable to restrict the maximum possible size of the next step h_{new} to h_{old} This also helps prevent oscillations in the step size.

It is clear that we will run into problems if the step size we choose gives an error of zero. A zero error might result because it is possible that we

Table 6: *The constants for the Runge-Kutta-Verner seventh-order method.*

j \ m	c	B(j,m) 1	2	3	4	5	6	7	8	9	10
1	0										
2	1/4	1/4									
3	1/12	5/72	1/72								
4	1/8	1/32	0	3/32							
5	2/5	106/125	0	−408/125	352/125						
6	1/2	1/48	0	0	8/33	125/528					
7	6/7	−1263/2401	0	0	39936/26411	−64125/26411	5520/2401				
8	1/7	37/392	0	0	0	1625/9408	−2/15	61/6720			
9	2/3	17176/25515	0	0	−47104/25515	1325/504	−41792/25515	20237/145800	4312/6075		
10	2/7	−23834/180075	0	0	−77824/1980825	−636635/633864	254048/300125	−183/7000	8/11	−324/3773	
11	1	12733/7600	0	0	−20325/5225	456485/80256	−42509/7125	339227/912000	−1029/4180	1701/1408	5145/2432
12	1/3	−27061/204120	0	0	40448/280665	−1353775/1197504	17662/25515	−71681/1166400	98/225	1/16	3773/11664
13	1	11203/8680	0	0	−38144/11935	2354425/458304	−84046/16275	673309/1636800	4704/8525	9477/10912	−1029/992
a(j)		13/288	0	0	0	0	32/125	31213/144000	2401/12375	1701/14080	2401/19200
a*(j)		31/720	0	0	0	0	16/75	16807/79200	16807/79200	243/1760	0
e(j)		−1/480	0	0	0	0	−16/375	−2401/528000	2401/132000	243/14080	−2401/19200

really do not have a truncation error at this step, or more likely, that the error is very small, and the machine sees the error as being zero due to round-off. This means that there is no problem with the step that we just took, but what do we do about the next step? If we used a value of zero for the error, we would in theory get an infinite range of step sizes for the next step, so an obvious policy to adopt in this case is to limit v to v_{lim}.

11	12	13
0		
0	$\frac{729}{341}$	
$\frac{19}{450}$		
0	$\frac{243}{1760}$	$\frac{31}{720}$
$-\frac{19}{450}$	$\frac{243}{1760}$	$\frac{31}{720}$

Stability Criteria

All Runge-Kutta methods (including the Euler method) have a range of step sizes beyond which the methods are unstable; that is, spurious results would be obtained from the algorithm. This becomes a problem with some types of differential equations and can be illustrated by solving the radioactivity problem $dN(t)/dt = -kN(t)$ with greatly varying values of the decay constant k.

It is possible to dedimensionalize the equation. In this case the equation would be written as $dN^*/dt^* = -kN^*$, and $N^* = N(t^*)/N_0$.

Now, the dimensionless time, t^*, would vary from 0 to 1. The analytical solution to this problem, again using dimensionless variables, would be $N^*(t^*) = e^{(-kt^*)}$.

If we try to solve this problem using the Euler method, we would have to choose a step size such that $0<=hk<=2$ to solve it correctly. For the Runge-Kutta-Gill method, the step size would have to be chosen so that $0<=hk<=2.8$. Tables 7 and 8 show the effect of changing the step size on the global error in the numerical solution of the problem $y'=-5y$ and $y'=-25y$, respectively, using the Euler and RKG-4 methods.

The cause of this instability is the propagation error I mentioned earlier. This error propagates faster if the slope of the function we are tracking is changing rapidly, causing the global error in turn to escalate rapidly. Reducing the maximum possible step size has the effect of reducing the truncation error to a level at which the propagation-error component in the global error does not increase dramatically. From this we conclude that a higher-order method is preferable since the region of stability is increased, and also that, for a given method, reducing the step size sufficiently will get the method to operate within a region of stability. However, if we were to keep increasing the value of k, we would eventually reach a point at which any algorithm would be taking such small steps that the method would become unworkable in practice. Note that the stability constraints on the step size imply that neither the Euler nor RKG-4 method would ever be able to solve a radioactivity problem with a negative value of k (such a value for k is only mathematically possible). Stability criteria are much more difficult to establish for Fehlberg and Verner methods. For the example I have provided for BYTEnet Listings, none of the three methods I used has any problems solving $y'= -25y$ over the interval $t = [0,1]$, but the relative error began to grow as $t=1$ was approached.

Stiffness

With a system of equations, one of the equations may change much more rapidly than the others. For example, a system of equations that describe a certain chemical reaction described in reference 9 is $y'_1 = -1000y_1 + y_2$ and $y'_2 = 1000y_1-2y_2$. The true solution is given in equations 2.7.

Notice that y_1 will rapidly decay to very small values, while y_2 will require a long time to decay to similar values. Because of this function, the algorithm is forced to choose extremely small step sizes to keep the errors within bounds and also to operate within a region of stability. A system of differential equations in which one or more differential equations have solutions that change so rapidly that the algorithm is forced to take prohibitively small steps to keep the error within bounds and the system stable is said to be a "stiff" system.

When we come up against stiffness in a system or instability in a single equation, there is very little we can do with the Runge-Kutta schemes described here other than to warn the user that the problem has arisen and stop the solver. If stiffness is encountered in a system, the step-size algorithm will try to meet error-tolerance specifications and maintain stability by drastically reducing the step size. If we specify a minimum possible step size h_{min}, then we can assume the system is stiff if the step size goes below this value. The h_{min} may be set by the program or by the user. A value of about 10^{-6} was found

(continued)

to work reasonably well; however, an acceptable value of h_{min} will depend on the size of the interval and the degree of stiffness desired.

If the function being tracked is discontinous over the range of interest, then our program must signal to the user that all is not well. For example, the solution to the differential equation $y'=y^2$, where $y(0)=1$, is $y(x)=1/(1-x)$, which would have a discontinuity at $x=1$. So if we attempted to solve the equation over the range $x=0$ to $x=2$, a drastic reduction in the step size would result as the algorithm attempted to track the rapidly varying function at the discontinuity, causing the step size to drop below h_{min}.

Setting a maximum possible step size h_{max} is also desirable, or the step size could grow indefinitely if we are solving over a large interval. The h_{max} is set to 0.5, 1.0, and 2.0, for the fourth-, fifth-, and seventh-order methods, respectively. These are just guideline figures. If these values are greater than the interval length, then h_{max} is set to the interval length. It is also possible to attempt to control the stability problem mentioned above, by imposing an upper limit on the step size. In this case a small number is used for h_{max}, but since the exact value is dependent on the nature of the problem, it is best to let the program use one of the guideline values or the interval width, with the ultimate choice for h_{max} left to the user.

Listing 1: *The procedure in pseudocode for predicting the values of u_{i+1} in the* RKF-4 *method.*

```
for n=1 to NEQN
  K1(n)= h*fn(xi,ui(n))
     {by calling user's subroutine containing equations for y'(n)}
end.
for j=2 to q
  for n=1 to NEQN
     ksum=0
     for m=1 to (j-1)
        ksum = ksum + bj-1,m*Km(n)
     end.
     us(n)=ui(n)+h*ksum
  end.
  Kj(n) = fn(xi+h*cj, us(n)) [n=1,..,NEQN]
end.
for n=1 to NEQN
  ui+1(n)=ui+ h*(a1*K1(n) + a3*K3(n) + a4*K4(n)+a5*K5(n)+a6*K6(n))
  ei+1(n) = h*(er1*K1(n) + er3*K3(n)+er4*K4(n) + er5*K5+er6*K6(n))
end.
```

Listing 2: A FORTRAN *subroutine to determine the machine epsilon.*

```
$NOFLOATCALLS
$NODEBUG
$STORAGE:2
C***********************************************
         subroutine caleps

c****    subroutine calculates the machine epsilon
c****    EPS using an algorithim adapted from
c****    Forsythe et. al. "Computer Methods for
c****    Mathematical Computations," Prentice-Hall
c****    (1977).  The EPS calculated can differ
c****    from the true machine EPS by at most
c****    a factor of 2.

         double precision eps
         common /epsil/eps

         eps=1.d0
10       eps=.5d0*eps
         if((eps+1.d0).GT.1.d0) goto 10
c        write(*,*) 'Machine Epsilon used=',eps
         return
         end
```

IMPLICIT METHODS

If the Runge-Kutta algorithm is written a little differently, so that the summation for the ks now goes from 1 to j (instead of $j-1$ as we had before), we get a class of algorithms called implicit Runge-Kutta methods. The general summation equation for the k's will be those shown in equation 2.8.

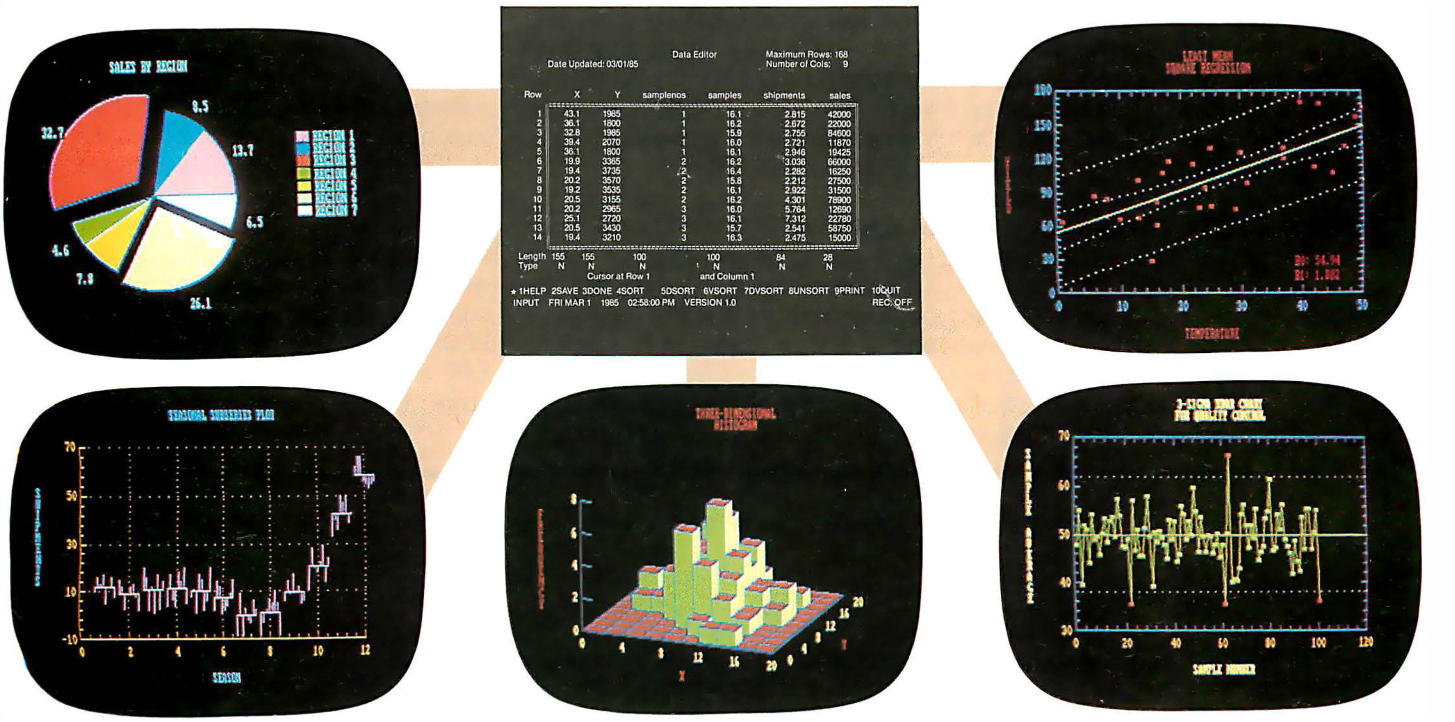
Now any k, say k_m will appear on both sides of the equation, so that an iterative scheme is required to solve for k_m. It is therefore much more tedious to obtain a value for k_m and make a prediction for y_{i+1} using this scheme. But the advantage of implicit Runge-Kutta methods is that they are inherently stable over all ranges of step sizes for all problems. By using an implicit method, all the problems of instability with stiff equations are overcome. M. L. Michelsen (see reference 10) has developed an algorithm using a semi-implicit form of the Runge-Kutta method in which one ends up with a set of linear equations for the k's. The parameters for the method have been chosen so that the equations for the k's may be solved by a single matrix inversion, allowing a standard LU (lower-upper triangular)

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decomposition technique to be used for their solution. This method has been shown to be stable for any type of IVP. However, the code for this method is involved, and a full discussion of this method is beyond the scope of this article.

SETTING ERROR TOLERANCE

If the solutions sometimes come close to zero, defining an absolute error tolerance (TOLA) on y as described previously is difficult because an extremely small value will be required around $y=0$ and a not-so-small value away from zero. This situation may be avoided by defining a relative error tolerance TOLR on y, so that TOLA = TOLR$\times y$. Some equations are solved more easily by defining an absolute error tolerance, so we provide a mixed error tolerance. That is, TOL = TOLA + TOLR.

MACHINE ACCURACY LIMITS

$F(x,Y)$ has to be evaluated at points such as $(x+h/4, y+hk_1/4)$, and h must be large enough so that the numbers x and $x+h/4$ are different in machine arithmetic. The smallest step taken on x is $h/18$ in the fifth-order method, so we need x and $x+h/18$ to be distinguishable on the machine ($x+h/18 > x$). For this to be the case, we must always have $h/(18x)$ be greater than the smallest positive real number representable on the machine without an exponent. This number, usually called machine epsilon (EPS), is also defined as the smallest positive number such that 1 + EPS > 1. EPS is dependent upon the machine, the compiler, and even the word length of the real-number representation being used. A FORTRAN subroutine that determines EPS to at most a factor of 2 of the "true" EPS is shown in listing 2.

(continued)

Table 7: *The propagation of global error on the numerical solution of $y'=-5y$ using the Euler and Runge-Kutta-Gill methods.*

ABSOLUTE GLOBAL ERROR ON *y(t*)*

*t**	Analytical solution	Euler method		Runge-Kutta-Gill method	
Step size		0.01	0.0002	0.01	0.00125
0.0	1.000000E+00	0.00000	0.00000	0.00000	0.00000
0.2	0.367879E+00	0.02553	0.5002E−03	−0.5430E−07	−0.1278E−10
0.4	0.135335E+00	0.05042	0.1000E−02	−0.1086E−06	−0.2555E−10
0.6	0.497871E−01	0.07466	0.1500E−02	−0.1629E−06	−0.3831E−10
0.8	0.183156E−01	0.09829	0.1999E−02	−0.2172E−06	−0.5107E−10
1.0	0.673795E−02	0.12130	0.2499E−02	−0.2715E−06	−0.6383E−10
Total function evaluations		100	5000	400	3200

Table 8: *The propagation of global error on the numerical solution of $y'=-25y$ using the Euler and Runge-Kutta-Gill methods.*

ABSOLUTE GLOBAL ERROR ON *y(t*)*

*t**	Analytical solution	Euler method		Runge-Kutta-Gill method	
Step size		0.01	0.0002	0.01	0.00125
0.0	1.000000E+00	0.00000	0.00000	0.00000	0.00000
0.2	0.67379E−02	0.5294	0.01246	−0.2006E−03	−0.4079E−07
0.4	0.453999E−04	0.7785	0.02477	−0.4012E−03	−0.8157E−07
0.6	0.305902E−06	0.8957	0.03693	−0.6019E−03	−0.1224E−06
0.8	0.206115E−08	0.9509	0.04893	−0.8026E−03	−0.1631E−06
1.0	0.138879E−10	0.9769	0.06078	−0.1003E−02	−0.2039E−06
Total function evaluations		100	5000	400	3200

The machine epsilon is an indicator of the attainable accuracy in a floating-point number system. The higher the value of EPS, the larger will be the effects of round-off error. We need $(h/18|x|) > \text{EPS}$ to prevent severe round-off error. Following the recommendation in reference 1, the machine epsilon used by the algorithm is set to 20×EPS for reasons of safety.

SUMMARY OF THE ALGORITHM

Finally, figure 3 summarizes everything I have said so far (plus shows a few extra trivial constraints) in a generalized algorithm for an explicit variable-step Runge-Kutta method that I call RUNKUT_SOLVER.

Procedure RUNKUT_SOLVER

INPUT: [order p, interval x_a to x_b, initial values $Y(x_a)$, first guess on step size h_{start}, name of function containing differential equations;Func.]

OUTPUT: [$Y(x_b)$, round-off error flag, stiffness/discontinuity flag.]

1. If first call to RUNKUT, evaluate machine epsilon and set **EPS** to 20*[machine epsilon].
2. If first call to RUNKUT or if p has changed since last call, evaluate constants
   - 2a. Evaluate vectors **a***, e, c, and the matrix B.
   - 2b. Set s to $(0.5)^{1/(p+1)}$.
   - 2c. Set S_{lim} to $(S_{lim,meth}/s)$, where $S_{lim,meth}$ = 3, 4, or 5, for p = 4,5, or 7, respectively.
   - 2d. Set h_{min} to program guideline value or user limit
   - 2e. Set $h_{max,set}$ to 0.5, 1.0, or 2.0, for $p=4$, 5, or 7, respectively.
   - 2f. Set q to 6, 8, or 13, for $p=4$,5, or 7, respectively.
3. Set h_{max} to Min.$[h_{max,set}, |x_a - x_b|]$.
4. Set the current step size h_{old} to the first guess h_{start}.
5. Call the PREDICTOR subroutine using Y_i and h_{old} to predict a value of Y_{i+1} and E_{i+1}.
6. Calculate v = Min.$\{[((\text{TOLA}+\text{TOLR}*|y(n)|)/e_{i+1}(n))]^{POWER}$ with **POWER** = $1/(p+1)$ or $1/p$, and $n=1,\ldots,$NEQN. If $y(n)=0$, set $y(n)$ to **TOLR**. If $e_{i+1}(n)=0$, use v_{lim} for that value of n.
7. Set h_{new} = Max.$\{h_{old}/10$, Min.$[h_{old}*s*$Min.$(v,v_{lim}),h_{max}]\}$.
8. Set round-off flag if $(h_{new}/18|x|)<$ **EPS**, for $|x| = 0$.
9. If $h_{new}<h_{min}$ set stiffness/function discontinuity flag, set x_b to x_{i+1} and $y(x_b)$ to Y_{i+1}, then **EXIT**.
10. If $v>1$ then set h_{old} to h_{new} unless there was a reduction of step size in the last step, in which case keep h_{old} unchanged.
11. Repeat steps 5 through 11 until $x+h_{old}\geq x_b$.
12. Set h_{old} to $x_b - x$.
13. Call PREDICTOR subroutine with this value of h_{old} to obtain $Y(x_b)$.
14. Set h_{start} to h_{old}.
15. Return to calling program.

Figure 3: *The outline of the algorithm for the author's Runge-Kutta solver program.*

My FORTRAN program (available on BYTEnet Listings) is based on this algorithm and has been written to solve IVPs. The program can solve any number of coupled equations, the limitation being the amount of memory available. The code consists of three main subroutines: RUNKUT, which is the solver, RKP, which is the predictor subroutine, and RKCONST, which sets all the constants. RUNKUT is called from the user's program, which also selects the order of the method to be used. The code has a number of refinements over the rudimentary algorithm outlined in figure 3. For example, it allows negative step sizes $(x_b < x_a)$ and it uses a "workspace" array that frees the user from having to make a large number of array declarations in the calling program. The order of the method being used may be changed while solving a given system of equations.

CONCLUSIONS

Runge-Kutta methods are an efficient and accurate way of solving IVPs. The advantage of Runge-Kutta methods over multistep formulas is that changing the step size is not as costly in terms of time. This allows the step size to be better adapted to the nature of the function. Runge-Kutta methods are also faster for nonstiff problems. The stability problems of the Runge-Kutta methods may be overcome by using one of the new semi-implicit algorithms. These are slower than the explicit methods—as are all implicit methods—because they require matrix inversion. Also, the only way to estimate the error (so far) is to use a half-step size for u^*_{i+1}. The ultimate program would be one that used both an explicit Runge-Kutta and an implicit (not necessarily Runge-Kutta) method. Then the explicit method could be used for solving the problem in regions where it is not stiff. As soon as stiffness was detected, the program would switch over to the implicit method until the stiffness died away.

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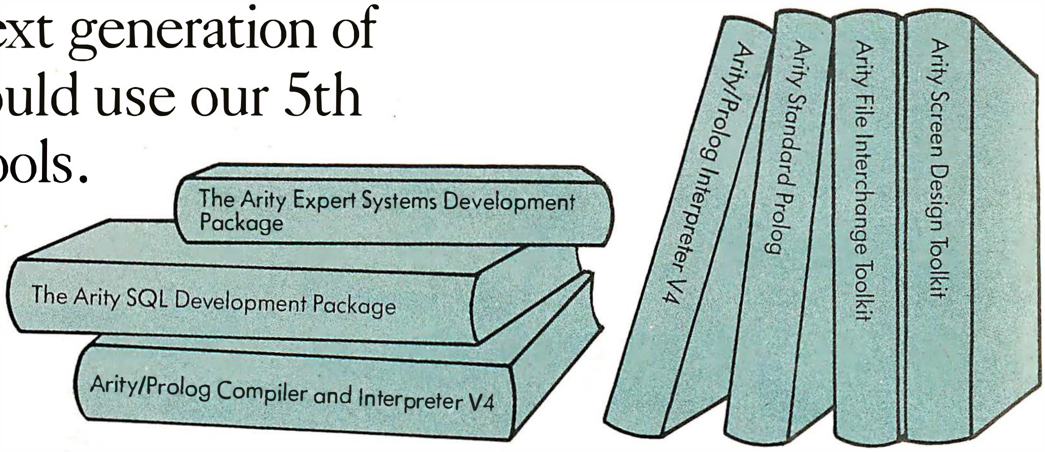
The program I developed solves systems of IVP ODEs without any significant problems. The error often had to be set at about an order of magnitude lower than what was actually obtained for the global error. However, for each of several test and actual problems, all methods met relative error tolerances of 10^{-6} without any difficulty. This order of accuracy is often enough for most engineering problems. It is possible to vary the accuracy and the speed of the codes provided by playing about with some of the parameters in the step-size adjustment algorithm. Therefore, I urge anyone so inclined to look at the effects of adjusting those values. Remember that the values for most of those parameters were determined on a trial-and-error basis, and the best values for a large number of general problems were selected. It is possible to optimize those parameters even further if only a particular problem (or a class of problems) is being considered.

Finally, these algorithms and codes, like all other numerical methods, are not infallible, and can occasionally give spurious results. So do not treat them as "black boxes" for solving differential equations. Often, examining a trend or a limiting case will indicate whether the results may be trusted. Sometimes, it is worthwhile to change the magnitude of the error tolerance (by a factor of say 10^{-2} or more) and check if this affects the results significantly. Also, reducing the maximum step size possible (h_{max}) to very small values will give solutions that are closer to the true solution—and a considerable increase in run times—so this may occasionally be used as a further check. ■

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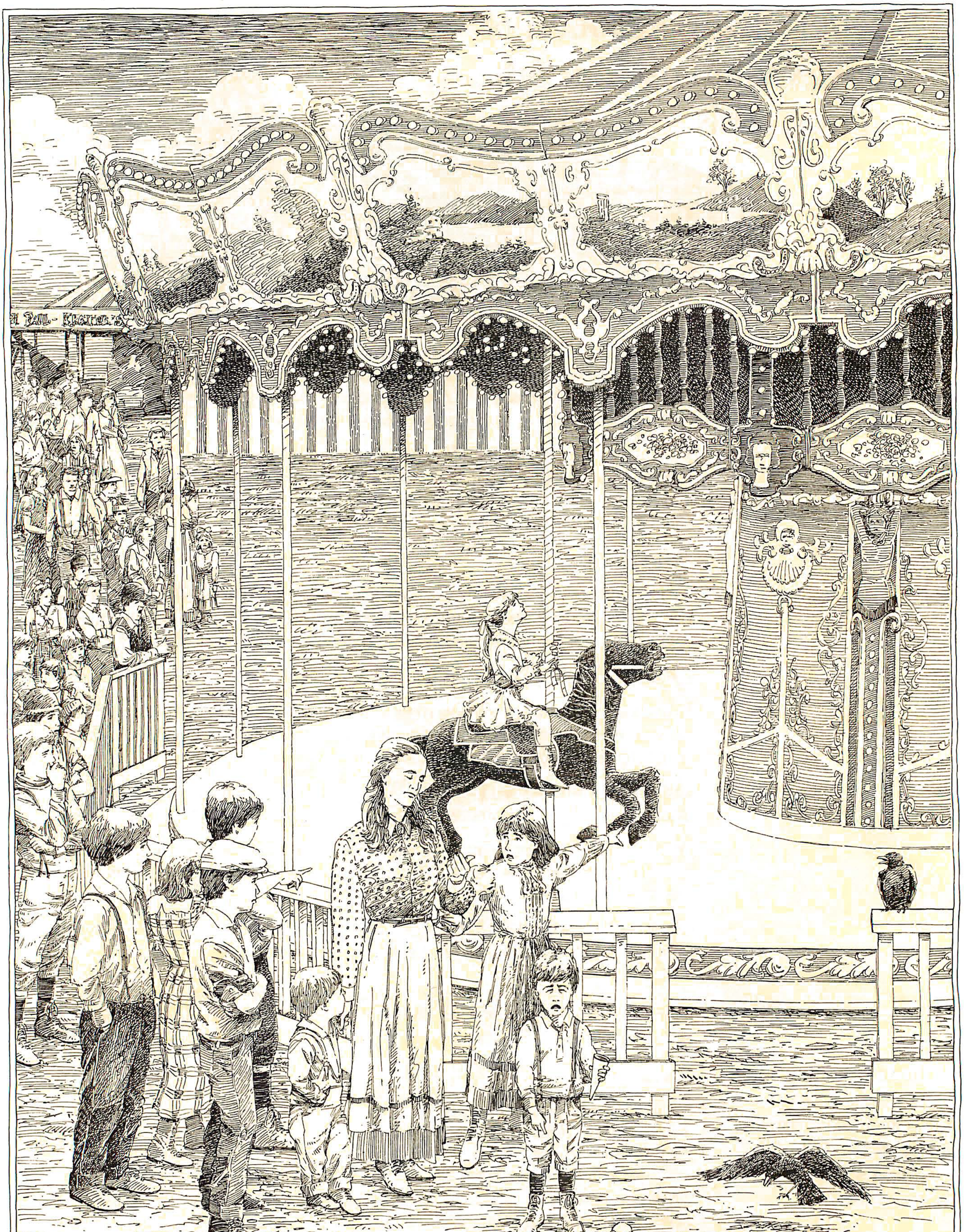
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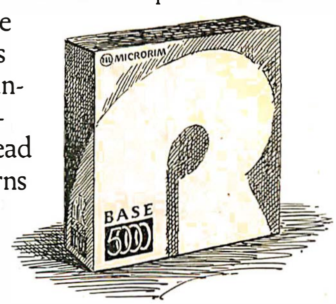
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THE ATOMCC TOOLBOX

BY Y. F. CHANG

Using Taylor series to solve ODEs

Editor's note: ATOMCC *is a* FORTRAN *program generator that creates* FORTRAN *source code to solve ordinary differential equations* (ODEs). *In order to use it, you create a data file called* ODEINP, *which specifies the* ODEs *of the system, initial conditions, etc.* ATOMCC *then creates a program called* ATSPGM, *which can be compiled to solve the problem.* ATOMCC.EXE *requires* MS-DOS *or* PC-DOS *and so is available only on those disk formats. The required* .OBJ *files mentioned in the article are included on the disk, as well as a* 121K-*byte* MANUAL.DOC, *which prints out to a* 55-*page user's manual that has copious examples of the program's use.*

ATOMCC *is available on disk as explained on page* 346 *or may be downloaded (onto* MS-DOS *disks, remember) via* BYTE*net Listings at* (617) 861-9764. *The sample output in listing* 2 *is available in all formats. Since* ATOMCC *is an executable file, no hardcopy output is available for it.*

IT IS POSSIBLE for an engineer, a scientist, or a mathematician to solve very complicated coupled systems of ordinary differential equations on a microcomputer using the ATOMCC toolbox. This toolbox has been used to solve simple student assignments as well as such involved problems as the detailed calculations of the orbit for Halley's comet. The ATOMCC toolbox is easy to use, and it automatically produces results that have hundreds and thousands of times better accuracy than those from the usual numerical methods available on mainframe computers.

Other important features of ATOMCC are the ability to solve most stiff problems automatically, the ability to stop and restart the solution on any specified value of any variable or any derivative of the variable, and the ability to search out all the singularities in the complex plane of the solution.

Briefly, stiff problems are those whose solution functions have a large negative exponential term, which causes a great deal of difficulty for all numerical techniques including ATOMCC. Stiff problems have to be handled in special ways in their solutions. Basically, you locate the large negative exponential term and factor it out.

The ability to stop and restart a problem solution automatically lets ATOMCC solve very complicated systems of ODEs, where you may wish to obtain precise information about the results at some particular configuration of the solution, such as the exact date and time of Halley's comet's closest approach to Earth or its closest approach to the sun.

A singularity is the point in a solution of a problem where the result is catastrophic. In nonlinear problems, the complex plane of the solution is full of these singularities, and they usually form some simple lattice. However, in the study of nonlinear dynamics, where some systems may exhibit chaotic behavior, the singularities may form complicated structures called fractals.

The ATOMCC toolbox has been used by a number of scientists at universities and research laboratories to study these fractal structures of singularities. While this feature of following a solution into the complex plane is not available in the usual numerical techniques on mainframe computers,

(continued)

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the ATOMCC toolbox provides it automatically.

The Runge-Kutta/Predictor-Corrector Methods

The usual mainframe-computer software packages used to solve ODEs are derived using either the Runge-Kutta method or the predictor-corrector method. These methods are based on approximations to the Taylor series. For example, a 4th-order Runge-Kutta method uses an approximation to a 5-term Taylor series, a 6th-order predictor-corrector method uses an exact fit to a 7-term Taylor series, and a 12th-order Runge-Kutta method uses an approximation to a 13-term Taylor series. Most of these usual methods for solving ODEs are relatively low-order methods, such as 4th or 6th orders. Since they are derived from rather low-order approximations to the Taylor series, they have poor accuracy control. Thus, there are two questions: (1) If these methods are based on approximations to the Taylor series, why not use the Taylor series itself to derive a numerical method to solve ODEs? (2) Since the low-order methods have difficulty producing highly accurate results, why not use very long Taylor series?

To answer the first question, there has been a misconception about Taylor series carried forward from textbook to textbook over several decades. We shall put it to rest here. At least one author has produced a "proof" that the higher-order derivatives of a function near a catastrophic singularity increase in magnitude without bound. He therefore concluded that one should not work with Taylor series, since the higher-order Taylor terms are derived from the corresponding-order derivatives. This "proof" is false, but there are two misleading facts that combine to make it seem like a valid proof.

First, the result of the proof is that the nth derivative of a function near a singularity is roughly the same size as the n-factorial. The factorials increase very rapidly to very large values. For example, 12-factorial is equal to 479,001,600, and 15-factorial is about the size of our national debt. This proof continues by concluding that the higher-order derivatives increase without bound just as the factorials increase without bound. This conclusion is misleading because one should really look at the ratio:

$$\text{Ratio} = \frac{\frac{d^n f}{dx^n}}{n!}$$

Note that this ratio is nearly a constant according to the proof. Therefore, instead of concluding that the derivatives increase without bound, the author should have concluded that the derivatives increase within bounds. The bounds are the factorials. Now, what are the Taylor series terms? The Taylor series terms are precisely the ratio given above! Therefore, in the final analysis, the correct conclusion is that the Taylor series terms do not increase without bound, but rather they are very well behaved with values that are nearly constant.

So, what had started out as being a false proof for showing that it is impossible to work with Taylor series has turned out to be a valid proof that Taylor series are quite nice to use as a computational tool. Such is the manner in which a misconception has been carried over the past several generations.

Since we now have a proof that Taylor series are well behaved, there is no problem in developing a very-high-order method for solving ODEs. The ATOMCC toolbox uses a 30-term Taylor series, which produces excellent accuracy control and fast execution.

Solving ODEs by Taylor Series

The ATOMCC toolbox contains an ODE-solving program generator that accepts statements of (1) the differential equations, (2) the initial conditions, (3) the domain of the problem, and (4) any method-controlling parameters. These statements are in standard FORTRAN format. The program generator produces a source program, which is in FORTRAN and is compiled and linked with the special library of subroutines in the ATOMCC toolbox. You do not have to write any program. The solution is given to you by ATOMCC automatically. As for the control of accuracy, I'll give a brief discussion on this subject below.

The convergence property of a short Taylor series cannot be determined by any means. There is insufficient information in the few terms of a short Taylor series for a reliable analysis of the truncation error. The short-series methods such as Runge-Kutta are forced into taking small incremental steps. This is because the short series does not properly approximate the function at the point of expansion. The many small steps give rise to the propagation of machine round-off errors. Thus, on a difficult problem the short-series methods are bound to produce results with accuracy much poorer than machine accuracy. While large steps give rise to truncation errors, small steps give rise to round-off errors.

The ATOMCC toolbox maintains very tight control over the accuracy of the computations. When the order of the method is high, say about 30, it is possible to find the exact positions of those catastrophic singularities in the solution function. It can be shown that there is a direct relationship between the behavior of Taylor series terms and the locations of singularities. The distance from the solution point to a singularity, defined as the radius of convergence, is the main source of the truncation error. When a computation step taken is larger than an allowable fraction of the radius of convergence, there will be appreciable error.

The accuracy of ATOMCC is totally dependent on the convergence analysis of long Taylor series. Not only does a long series allow for good error analysis, it allows for an integration step size much larger than that for a typical fourth-order Runge-Kutta method. When the order of the Taylor series is sufficiently high, it is possible to calculate or estimate the radius

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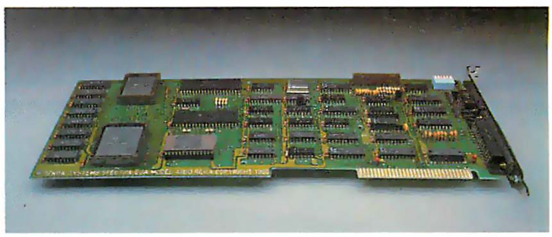
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With a long Taylor series you can calculate or estimate the radius of convergence.

of convergence. This information allows the integration step to be adjusted to keep the local error below a specified limit. In the ATOMCC toolbox, solutions of problems are calculated only after obtaining both the calculation for the radius of convergence and adjusting the integration step. When a singularity is near the solution path, ATOMCC will adjust the integration step to be very small to meet the accuracy requirements.

The ATOMCC analysis can be applied to linear and nonlinear problems alike. The bases of the ATOMCC analysis are the recursion relation obtainable from the equations of the problem and Leibnitz's rule, also called a Cauchy product. The solutions to all problems, linear and nonlinear, are in the form of Taylor series. Linear problems in ordinary differential equations have simple Taylor series solutions that may be evaluated without computers.

Major Advancements in this Version

The present version (7.10) of ATOMCC for microcomputers will solve stiff problems. This represents a significant departure from the central premise of the ATOMCC system, which is precise error control. For nonstiff problems, you still have the most accurately controlled numerical method ever developed. For many problems, the precision is so good that there is *almost* global error control.

For stiff problems, due to the nature of the "approximating" solution, there cannot be true error control. Therefore, the controlling parameter for errors in stiff problems (called ADJSTF) is only meant to be loosely referred to as an error control.

Another particularly useful feature in the current ATOMCC version is that all the dependent variables are now placed into a temporary two-dimensional array (TMPS) by an EQUIVALENCE statement. This allows you to reference each variable by an index value. For a system with x, y, and z as functions of t, the term $y(5)$ can be also referred to as TMPS(5,2). Similarly, $z(23)$ = TMPS(23,3).

Requirements of ATOMCC

The ATOMCC toolbox uses Microsoft FORTRAN-77 (a registered trademark of Microsoft Corporation) and works on a microcomputer operating under MS-DOS. To be able to run ATOMCC on your MS-DOS microcomputer you must have the following hardware and software: an MS-DOS computer with an 8087 coprocessor, at least 256K bytes of RAM, two floppy-disk drives or a hard-disk drive, and Microsoft FORTRAN-77 version 3.30.

A complete system includes the ATOMCC system disk files and the Microsoft FORTRAN-77 disk files. Of the ATOMCC system files, ATOMCC.EXE is the compiler that reads statements of differential equations and generates a FORTRAN program called ATSPGM. (The name ATSPGM for the output program file is fixed, but you may change it after it has been written by ATOMCC.) The other system files are the ATOMCC subroutine libraries: RDCV.OBJ (the ATOMCC subroutine library in single precision), DRDCV.OBJ (double precision), CRDCV.OBJ (complex), and CDRDCV.OBJ (complex double).

(continued)

 Inquiry 60

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(Cincinnati, Ohio) January, Tominy, Inc. announced the immediate availability of a single-user version of their Mach 1 System Genera ion Facility on the IBM PC.

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The Logical Data Base Structure of the Tominy products provide unlimited record sizes, multiple file keys, data independence, record locking and free space management. The Logical Data Base's flexible design supports Relational, Hierarchical, and Network Data Views.

Programs to maintain the Data Base can be completely generated by MACH 1. A MACH 1 Generated Program allows users to inquire on the Data Base and add, update, or delete Data Base information.

Ad hoc data analysis or reports are addressed by the MACH 1 Query/Report Generator. The simple "English-like" Query statements allow data to be selected, sorted, summarized, displayed and printed.

To allow for more complex transaction processing and reporting, MACH 1 contains the fourth-generation procedural language "LOGIC."

Fourth-Generation LOGIC Language

The LOGIC language provides the command structure to manipulate data; perform data base, screen and print I/O; control program flow; manipulate tables and arrays; log system messages; and perform mathematical calculations.

A standardized approach to program development is ensured using the "program framing" concept of the MACH 1 products. MACH 1 "frames" the LOGIC code by "writing" the complete data variable section, and including various LOGIC modules.

This approach to application development ensures a consistent structure while still providing the flexibility required by the serious application developer.

The LOGIC programs are tested on-line using the Interactive Program Tester which steps through the execution of the LOGIC code and permits immediate changes to the program statements, variable values, and the test data base.

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The MACH 1 is a menu driven package. It is simple and easy to use. Full-screen text editors are included for entering the LOGIC code, Job control statements, and Data Base Descriptions.

On-line HELP screens are provided to guide the developer through the numerous utilities provided with MACH 1. In addition, the MACH 1 manuals walk the owner through designing, developing, testing, packaging, and maintaining their Application System.

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Listing 1: *A sample* ODEINP *file, used to create listing* 2 *with* ATOMCC.

```
C FIRST PAINLEVE TRANSCENDENT
      DIFF(Y,T,2) = 6.0*Y*Y + T    $
      $
C READ INTEGRATION INTERVAL AND INITIAL CONDITIONS.
      READ(5,1010) START,END,Y(1),Y(2)
 1010 FORMAT(4F10.3)
      WRITE(*,1020) START,END,Y(1),Y(2)
 1020 FORMAT(' SOLVE THE FIRST PAINLEVE TRANSCENDENT' /
     + ' INTERVAL:           ',2F10.3 /
     + ' INITIAL CONDITIONS:',2F10.3 /)       $
      $
```

Listing 2: *The output file* ATSPGM *created by* ATOMCC *from the listing* 1 *file.*

```
c**********
c     This program was produced by the  ATOMCC
c     translator version 7.10 Copyright (C) 1985,
c     Y. F. Chang
c*********************************************
c Portions (c) Copyright, Microsoft Corp., 1981.
c All rights reserved.
c This program was written for the following inputs
c
C FIRST PAINLEVE TRANSCENDENT
C     DIFF(Y,T,2) = 6.0*Y*Y + T
c--------
c no instructions in second input block
c--------
      COMMON /IPASS/ LENSER,LENVAR,MPRINT,MSTIFF,LRUN,
     + KTRDCV,KNTSTP,KTSTIF,KXPNUM,KDIGS,KENDFG,NTERMS,NOPT
     A /RPASS/ RADIUS,ERRLIM,ADJSTF,RCREAL,RCIMAG,RDCERR
     B /CPASS/ START,END,ORDER
     C /DPASS/ H,HNEW,XPRINT,DLTXPT
      DIMENSION TMPS(  36,   1)
      CHARACTER*6 NAMES
      EQUIVALENCE (TMPS(1,1),Y(1))
      DIMENSION NAMES(1),Y(36),T(2),TMPAAB(30),TMPAAA(30)
      DATA NAMES(1)/'Y.....'/
      Y(33) = 1.1
   10 FORMAT(72H   ATOMCC  Ver. 7.10, Copyright (C) 1985,
     A Y. F. Chang; Solution results./9H    ******)
   11 FORMAT(/5X,11HStep number,I6,13H at the point,
     A1P1E12.4/1X,9Hvalues of )
   12 FORMAT(1X, A6,(1X,1P4E13. 5))
   13 FORMAT(5X,21HStepsize adjusted to ,1PE13.5)
   14 FORMAT(/5X,35HThe solution stopped normally after,
     A I4,24H steps as set by nsteps. )
   16 FORMAT(/5X,63HThe adjustment for stepsize seems to
     A be in a loop. Please try a /5X,22Hshorter series
     A length. )
      WRITE(*,10)
c--------
c Initialize variables to default values
c--------
      NSTEPS = 40
      H = 1.E0
      ERRLIM = 1.E- 6
      LENSER = 30
```

(continued)

The Microsoft FORTRAN-77 files are described in the Microsoft manual. The relevant files are FOR1.EXE, PAS2.EXE, LINK.EXE, and FORTRAN.LIB.

To use ATOMCC, you create a file called ODEINP (this name is fixed within ATOMCC). ODEINP contains four separate blocks, each ending with a $ delimiter (see listing 1). The first block contains the system of ODEs, written in FORTRAN. These equations are processed by ATOMCC to determine the recurrence relations that are written into ATSPGM to generate the Taylor series for each component of the solution. The second block (empty in listing 1) can be used to insert nonexecutable FORTRAN statements (e.g., SUBROUTINE, DIMENSION, or COMMON) at the beginning of ATSPGM. The third block is used to specify the interval of integration and the initial conditions. In the sample program, these values will be read from disk. Alternatively, they may be explicitly declared. The fourth block is usually empty. It may be used to insert statements into ATSPGM at the end of each integration step. The second, third, and fourth blocks are not processed syntactically by ATOMCC; they are copied directly from ODEINP into ATSPGM.

The output ATSPGM file created by using the ODEINP file in listing 1 is shown in listing 2. ATSPGM is a standard FORTRAN source-code file: You may edit and modify it like any other source code.

APPLICABILITY

The ATOMCC method can solve stiff and nonstiff systems of initial value problems in ordinary differential equations in which the highest-order derivative of each dependent variable is given explicitly on the left-hand side of an equation whose right-hand side has a finite sequence of +, −, *, /, **, EXP, SIN, COS, TAN, SINH, COSH, TANH, ALOG, ACOS, ASIN, ATAN, or any function that is the solution to a differential equation.

The known limitations of ATOMCC

(continued)

```
      MPRINT = 4
      NTERMS = 2
      KTRDCV =  1
      ADJSTF = 1.E-2
      MSTIFF =  0
      DLTXPT = 0.E0
c--------
c start of third  input block
c--------
C READ INTEGRATION INTERVAL AND INITIAL CONDITIONS.
      READ(5,1010) START,END,Y(1),Y(2)
 1010 FORMAT(4F10.3)
      WRITE(*,1020) START,END,Y(1),Y(2)
 1020 FORMAT(' SOLVE THE FIRST PAINLEVE TRANSCENDENT' /
     + ' INTERVAL:             ',2F10.3 /
     + ' INITIAL CONDITIONS:',2F10.3 /)
c--------
c end of third  input block
c--------
c More initializations
c--------
      DLTXPT = SIGN(DLTXPT,(END-START))
      H = SIGN(H,(END-START))
      KDIGS =  6
      XPRINT = START + DLTXPT
      KXPNUM = 35
      LENVAR = 36
      LRUN = 1
      KTSTIF = 0
      NUMEQS =    1
      IF(LENSER.GT.(LENVAR- 6)) LENSER = LENVAR -  6
      IF(MPRINT.LT.2) GO TO 17
      WRITE(*,11) KTSTIF,START
         K = Y(33)
         WRITE(*,12) NAMES(K),Y(1), Y(2)
c--------
c Loop for integration steps.  Inside the loop,
c print the desired output
c--------
   17 DO 27 KINTS=1,NSTEPS
         KOUNT = 0
         KNTSTP = KINTS
   19    CONTINUE
         T(1) = START
         T(2) = H
         Y(2) = Y(2)*(H)
c--------
c Preliminary series calculations
c--------
         TMPAAA(1) = 6.E0*Y(1)
         TMPAAB(1) = TMPAAA(1)*Y(1)
         Y(3) = (TMPAAB(1) + T(1))*(H*H/2.E0)
         TMPAAA(2) = 6.E0*Y(2)
         TMPAAB(2) = TMPAAA(1)*Y(2) + TMPAAA(2)*Y(1)
         Y(4) = (TMPAAB(2) + T(2))*(H*H/6.E0)
c--------
c Loop for series calculations
c--------
         DO 23 K= 5,LENSER
            KA = K - 1
            KB = K - 2
            TMPAAA(KB) = 6.E0*Y(KB)
            TMPAAB(KB) = 0.E0
            KZ = 1 + KB
            DO 30 N=1, KB
               L = KZ - N
```

(continued)

are that the derivatives may be of an order of, at most, 6 and that there are, at most, 900 equations in the system.

ATOMCC can also solve (with manual intervention) solutions that are polynomials, singular problems that require the application of l'Hospital's rule, or problems that have catastrophic subtractive errors in series generation.

ATOMCC is most attractive for problems with stringent accuracy requirements, stiff problems, problems that must be solved repeatedly (such as parameter identification), or quick and easy problems (students' assignments).

The very high order and precise error control used by ATOMCC have enabled it to solve many problems that other methods were unable to solve.

The ATOMCC toolbox allows for the solution of ODEs in the complex domain. This unique capability can be used to explore the structure of the singularities in the complex domain of nonlinear problems. The analytic information about the location and order of singularities in the solution provides insight into the behavior of the system. This method has been used to map the first mathematical natural boundary discovered in the solution of a nonlinear dynamics problem.

The complexity and execution time of ATSPGM depend on the number of functions and on the number of multiplications in the ODE system, not on the number of equations in the ODE system nor on the order of the derivatives involved. There is no penalty for high-order derivatives.

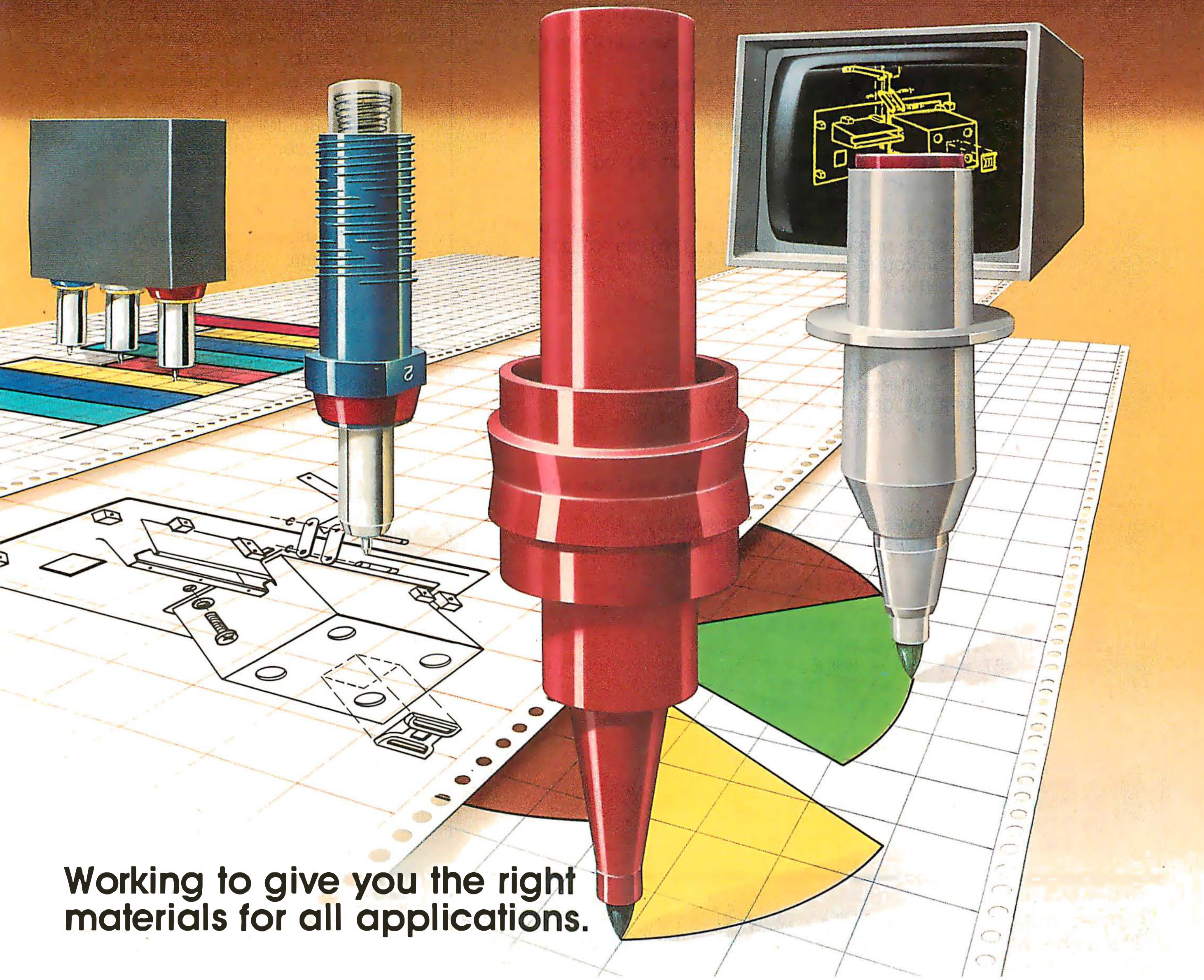
As with all numerical methods, there is no substitute for insight into the structure of the ODE system and for the application of clever transformations.

THE GENERATED PROGRAM, ATSPGM

The ATSPGM program implements the Taylor series algorithm for solving initial value problems in ordinary differential equations. This Taylor series

(continued)

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```
              TMPAAB(KB) = TMPAAB(KB) + TMPAAA(N)*Y(L)
   30           CONTINUE
           Y(K) = (TMPAAB(KB))*(H*H/(KB*KA))
c--------
c Test and adjust H to avoid over/under flow
c--------
           IF(MSTIFF.GE.20 .AND. KTSTIF.GT.0) GO TO 23
           TMP = ABS(Y(K))
           IF(TMP.LE.1.E-35) GO TO 23
           IF(TMP.LT.1.E20 .AND. TMP.GT.1.E-20) GO TO 23
           IF(KTSTIF.NE.0 .AND. TMP.LT.1.0) GO TO 23
           KOUNT = KOUNT + 1
           IF(KOUNT.LT.9) GO TO 22
           WRITE(*,16)
           GO TO 28
   22      CONTINUE
           Y(2) = Y(2)/(H)
           H = H * TMP**(0.3/(1-K))
           IF(MPRINT.GE.4) WRITE(*,13) H
           GO TO 19
   23    LRUN = 1
c--------
c Calculate radius of convergence and take optimum step
c--------
         CALL RDCV(TMPS,LENVAR,NUMEQS,NAMES)
   24    CALL RSET(TMPS,LENVAR,NUMEQS,NAMES)
c--------
c no instructions in fourth input block
c--------
   25    GO TO (26,28,24), KENDFG
   26    H = SIGN(RADIUS,H)
         START = START + HNEW
         IF(MPRINT.LT.4) GO TO 27
         WRITE(*,11) KNTSTP, START
         K = Y(33)
         WRITE(*,12) NAMES(K),Y(1), Y(2)
   27 CONTINUE
      WRITE(*,14) NSTEPS
   28 CONTINUE
   29 STOP
      END
```

algorithm, in outline, is as follows: Initialize method control parameters that may be modified; assign initial conditions, the integration interval, and method control parameters; initialize method control parameters that may not be modified; and loop for each integration step. To do this, initialize the first few series terms; generate the entire series; call subroutine RDCV to determine the optimal step size from (a) the location and order of the primary singularities, (b) the series length, and (c) the error tolerance and then adjust the step size; and then call subroutine RSET to perform analytic continuation and to print the solution.

In ATSPGM, the step size used to expand the series is related to the radius of convergence at each integration step. After a series is generated, the location and order of the primary singularity are calculated. Then, the step size is adjusted to control the error.

An exception is made in the solution of stiff problems. The step size is determined in stiff problems by the length of a polynomial that can adequately represent the function. ■

The ATOMCC toolbox presented in this article is a microcomputer version of the original mainframe system. Institutions interested in porting ATOMCC to their mainframes should contact the author for source code and support.

ACKNOWLEDGMENTS
I would like to express my gratitude to Roy Morris for the initial design and coding of the translator program; to students John Fauss, David Lowery, and Manuel Prieto for their work on series analysis; to Ray Moore, Mike Tabor, John Weiss, Mike Ziegler, Phil Bender, and others for many helpful suggestions; and to Jon Wright for the many suggestions that arose from his extensive use of the ATOMCC system. I am particularly indebted to Professor George Corliss, who assisted me in every aspect of this program.

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Reviews

IN OUR FIRST REVIEW we take a look at one of an intriguing class of transportable computers that features a high-speed processor, an integral printer, and a crisp gas-plasma display. The Panasonic Exec. Partner, according to BYTE Senior Technical Editor Rich Malloy, has made some strides in presenting remarkable new examples of technology at a comparatively low price. On the other hand, he notes that the Exec. Partner is a hefty 28 pounds. That's a lot of bulky, delicate electronic gear to try hauling home on the bus. Beyond the screen itself, how well does the machine measure up to other choices you could make for the same money?

Our next review is of KAMAS, an outline processor and programming language that, according to reviewer Albert Woodhull, gives you considerable freedom in document organization and preparation. KAMAS is described as being "layered like an onion," in which the user discovers successive levels of capability. Starting from the outer layer and working in, you pass through an outline editor and a "leaf" editor to get to a deeper level of screen-oriented layers where you can use all the outline-processing commands from a line-oriented terminal. A still-lower level gets you into programming and lets you specify commands and their arguments either in command lines or as text in a file. Finally, two more programming levels constitute "a general-purpose, extensible, threaded-interpretive language," similar to FORTH. All the features and layers have a purpose in helping you organize your writing, and this review gives you a full explanation of them.

The IBM Professional Debug Facility and the Advanced Fullscreen Debug are compared and contrasted in our next review. According to Jack Carden's analysis, there are considerable areas of similarity between the two. Generally, they each contain most of the features usually available in standard debuggers. They have considerable functionality and each constitutes a valuable tool for the programmer. Nevertheless, the two facilities aren't carbon copies of each other, and the differences provide an interesting look at the number of ways you can go about cleaning up your code.

The time-series regression package microTSP is the type favored by economists and other social scientists. Down-sized from TSP International's mainframe-oriented Time Series Processor, microTSP nevertheless reveals a high level of functionality and ease of use, according to reviewer Paul Davenport of McGill University. The program runs on the IBM PC and such compatibles as the Compaq, requires two disk drives, 256K bytes of RAM, and PC-DOS. Professor Davenport reports that, except for the perennial problem of less-than-sparkling documentation, the program is straightforward, easily understood, and a tool for statistical manipulations that you can start using to good advantage with a minimum of preliminaries.

Lastly, we have a comparison of two professional-quality typesetting programs for use on IBM PCs and compatible MS-DOS microcomputers. PCTEX and MicroTEX are decendants of the powerful TEX program developed by Donald Knuth of Stanford University. The software is especially valuable for setting such "penalty" text as mathematics, tables, foreign languages, and technical material.

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CED Program Editor — $29.95

CED now supports on-line function help. If you've forgotten how to use a standard library function, just type in the name of the function and CED gives you a brief summary, including function arguments. CED is a full screen editor with auto-flagging of source code errors, multiple windows, macros, and is fully configurable to suit your needs. You can edit, compile, link, and execute DOS commands from within the editor. Perfect for use with Eco-C88. For IBM PC, AT and look alikes.

C Source for Standard Library — $10 ($20 if not with order)

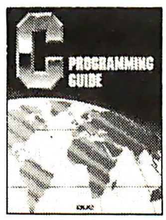
Contains all of the source code for the library functions that are distributed with Eco-C88, excluding the transcendentals and functions written in assembler.

Developer's Library — $25 ($50 if not with order)

Contains the source code for all library functions, including the transcendentals and those written in assembler. Perfect for the developer that wish to write their own custom functions or learn how we implemented the Eco-C88 library.

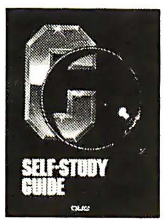
ISAM Library — $15 ($30 if not with order)

Contains the code from the **C Programmer's Library** in relocatable format (i.e., .OBJ) including the delete code for the ISAM file handler.



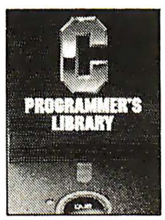
C Programming Guide — $20

After reading the 1st edition, Jerry Pournelle (**BYTE** Magazine) said: "I recommend this book... Read it *before* trying to tackle Kernighan and Ritchie." The second editon expands this best seller and walks you through the C language in an easy-to-understand manner. Many of the error messages include references to this book making it a perfect companion to Eco-C88 for those just starting out with C.



C Self-Study Guide — $17

(Purdum, Que Corp.). Designed for those learning C on their own. The book is filled with questions-answers designed to illustrate many of the tips, traps, and techniques of the C language. Although written to complement the Guide, it may be used with any introductory text on C.



C Programmer's Library — $20

(Purdum, Leslie, Stegemoller, Que Corp.). This best seller is an intermediate text designed to teach you how to write library functions in a generalized fashion. The book covers many advanced C topics and contains many useful additions to your library including a complete ISAM file handler.

Eco-C88 C compiler requires an IBM PC, XT, or AT (or compatible) with 256K of memory, 2 disk drives and MSDOS 2.1 or later. Call today:

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TRADEMARKS: ECO-C88, ECOSOFT

We were recently handed the Datavue 25 from Quadram and a Z-171 PC from Zenith, which have upgraded, backlit LCD screens and contain more memory than previous flat-screen, sewing-machine-style carry-alongs.

They are both light, but because of their upright profiles, neither of these machines are laptops. The Datavue 25's cordless, detachable keyboard gives you some freedom from the system unit, but since it transmits keystroke information by means of infrared LEDs, you have to maintain a clear line of sight between yourself and the front of the computer. You're going to have a dead keyboard if the keyboard drops below the edge of a table or if you turn in your chair to see who's standing at your office door. For the most part, when you're pointing the keyboard in the general direction of the Datavue 25's front panel, you'll find that transmission is reliable. I started missing characters occasionally when I held the keyboard on my lap and the system unit was in front of, and a little lower than, my knees. I may have been unconsciously trying to compensate by hitting the keys harder (and maybe someone who never used a manual typewriter wouldn't react at all the way I did), but after a few hours, I understood why Quadram said one of its beta testers complained of sore fingers.

The new Datavue has a single disk drive. It also has 640K bytes of RAM, however, and you can set aside up to half of that as a RAM disk. You can get out of a lot of tedious disk swapping by using the RAM disk, as long as you log your data to a floppy and have a relatively reliable electrical outlet or use the batteries. The Zenith has two disk drives. You don't have to set up a RAM disk but, of course, disk-intensive programs will run slower.

Right away people are going to notice the brighter screens on both these computers. You can read words and numbers off these new screens without squinting at punctuation marks or decimal points, for example. A very bright light source at the wrong angle will still wash out the LCD, but the light has to be brighter than it used to and there are fewer really bad angles.

The Quadram unit comes with its own DOS and a diagnostics disk. I tried booting it with the DOS disk from my Compaq without success. The Zenith seemed to boot just fine on several varieties of MS-DOS. The Zenith also has some useful-looking built-in programs for keeping track of appointments, etc.

Another upgrade, and one for which there will also be more coverage in coming issues, was the Macintosh Plus. While the new machine is an upgrade in itself and can be purchased in its full configuration, a good deal of discussion is focusing on the stepwise upgrades for current Macintosh owners. The first is a new ROM and a double-sided 800K-byte drive, with the second being a megabyte of RAM and a new back panel designed to take an external SCSI port. Both of these are supposed to be done by Apple dealers. There is a third upgrade, a new keyboard with numeric pad and cursor keys, but since this doesn't require anything beyond plugging it in, most people seem to be viewing it as a new feature instead of an upgrade.

The memory upgrade for current Macintosh owners costs $200 more ($799) if your Mac has 128K bytes of RAM than if it has 512K. If you had your 128K Mac upgraded by someone other than Apple, you pay $799 as well. People who bought a new Macintosh between the middle of November and the middle of January, or had their 128K Mac upgraded to a 512K version during that time, will get rebates on upgrade kits.

Lisa and Macintosh XL owners are being invited to take part in the upgrade by swapping their old machines and about $1500 for a new Macintosh Plus and a 20-megabyte hard disk. Apple isn't creating a schedule of discounts to take into account the different configurations and original prices of the Lisa and the XLs they're taking in trade. There is one price for all.

So far, all the applications that ran on earlier Macintoshes run on the Plus. The increase in speed due to extra memory, memory cache, and new system software is especially noticeable when you're moving around in an application (scrolling through a large document, for example) where you'd gotten accustomed to daydreaming while the Mac poked along. It's quite a change to have to pay attention so that you don't wind up making the machine wait instead of the other way around. Old single-sided disks continue to work, and programs and languages can be run with few or no problems, in our experience.

You'll become more appreciative of the upgraded Macintosh if you've had some experience fidgeting in front of the older versions. I'm not sure how a new user will view the features that I look at favorably. Still, they're the kind of improvements in Macintosh that people have been waiting for Apple to produce for some time. Others have done it, now Apple has done it, and those people who wanted both expanded capability and an intact warranty will probably be reassured.

—Glenn Hartwig
Technical Editor, Reviews

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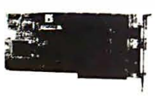
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S·Y·S·T·E·M R·E·V·I·E·W

The Panasonic Exec. Partner

This new transportable features a gas-plasma display and a built-in thermal-transfer printer

BY RICH MALLOY

The Panasonic Exec. Partner is a new transportable IBM PC-compatible computer that comes with not only a high-speed processor and an integral printer, but also a gas-plasma display.

The gas-plasma display is an exciting new technology. By setting the price of the Exec. Partner at $2595, Panasonic has made this technology affordable. The question is whether the other elements of the Exec. Partner are equally exciting.

PHYSICAL DESCRIPTION

The Exec. Partner looks much thinner and taller than other transportables. In fact, because it may fall over when you stand it on its side, Panasonic recommends that the machine be left lying flat at all times.

One advantage of this thin design is that you can carry it close to your side. Unfortunately, it weighs 28 pounds and seems just as heavy as other transportable computers. I wouldn't want to carry it home regularly.

When set up for use, the thin design gives the machine a low, sleek professional look. In fact, it looks like a large portable electric typewriter, but it's a little longer front to back (21.7 inches). The housing of the display, which acts almost as a keyboard cover, swivels up, revealing the keyboard, the display, and the disk drives. This feature should offer some protection for the system.

Unfortunately, the top of the display housing has a number of ventilation holes located above the electronics inside the display. Thus, even with the display closed, the display electronics are not protected if you spill liquids on the system.

On the right side of the machine is an opening for a short expansion board, such as an internal modem. Adjacent and to the rear of this opening are the 120/220-volt power-selector switch, power on/off switch, and the main power fuse, respectively. On the rear panel from left to right are the connectors for power, the parallel printer port, the serial port, and an expansion connector. (See the rear-view photo in the "At a Glance" box on page 234.) Immediately above the connectors is the printer access door.

The rearmost four inches of the machine is light gray and houses a thermal-transfer printer. The contrasting color gives the impression that the printer portion can be removed, but unfortunately, this is not the case.

GAS-PLASMA DISPLAY

The best feature of the Panasonic Exec. Partner is its high-contrast gas-plasma display of light-orange characters on a dark-orange background (see photo 1). This display is quick and steady, and each dot is sharp and precise.

In text mode, the display has a fairly high resolution (640 by 400 pixels). Each text character is formed on an 8- by 16-pixel matrix and is very easy to read. By contrast, the IBM PC monochrome display uses a 9- by 14-pixel matrix for each character. In addition, the display is rather large, 11 inches diagonally, compared with the 9-inch diagonal displays on the Compaq and IBM transportables.

The display is very flat, but reflection on the display face does not seem to be a problem. Because of a unique hinge, the display can be set at any angle for easy reading. This is in contrast to other transportables whose displays are limited to a single open position.

As good as the Panasonic display is, it does have a little trouble being compatible with the IBM displays. Panasonic has chosen to emulate the IBM Color Graphics Adapter (CGA), which has the advantage of allowing the system to display graphics. Unfortunately, most software that uses the CGA will attempt to make use of the CGA's 16 text colors, and the Exec. Partner cannot display color. Instead, it represents these 16 colors by using only four text styles: normal, bold, italic, and italic bold.

(continued)

Rich Malloy is BYTE's New York editor. He can be reached at BYTE/McGraw-Hill, 43rd Floor, 1221 Avenue of the Americas, New York, NY 10020.

The result is that text that is beautifully highlighted in color may not be highlighted at all on the gas-plasma display.

Because of the Exec. Partner's monochromicity, it is surprising that Panasonic did not choose to match its text styles with those of the IBM Monochrome Adapter (for example, normal, high-intensity, underlined, etc.). This might have somewhat alleviated the problem of handling multicolored text. Fortunately, however, most software for the IBM PC lets you alter the text colors the programs use, allowing you to choose the optimum combination for the Exec. Partner.

Another problem I noticed is that, for some reason, Borland's desk-accessory program SideKick changes the way other programs use the text modes. I suspect that Panasonic has used some unusual mapping technique, or SideKick is very sensitive to some esoteric section of the display BIOS.

The italic modes of the display are impressive, but I wish that Panasonic had made its system more compatible with the IBM or the Compaq. I also wish that Panasonic had adapted another feature of the Compaq, a connector for an RGB display.

KEYBOARD

The Panasonic Exec. Partner keyboard is similar to the IBM PC keyboard except for three details. The function keys are aligned horizontally along the top of the keyboard; certain important keys such as Return, Shift, and Backspace are oversize for ease of use; and there is a row of indicator lights above the numeric keypad that indicate functions such as Caps Lock and Num Lock.

Note that the keyboard has the same misplaced left Shift key as the IBM PC. The keyboard seems to have a good feel. Unlike a detachable keyboard, however, it cannot easily be moved around on a desk.

ELECTRONICS

The 8086-2 microprocessor seems to be increasingly popular in new systems and is put to good use in the Panasonic machine. The 8086-2 can run at two clock speeds. In high-speed mode the processor has a clock speed of 7.16 MHz. This clock speed, combined with the wide (16-bit) external data bus of the 8086, allows the Panasonic to run at almost twice the speed of the IBM PC (see the benchmark results).

In low-speed mode, the clock speed reverts to 4.77 MHz, and the processor runs at nearly the same speed as the 8088 in the IBM PC. The low-speed mode is important for situations where you might want complete compatiblity with the IBM PC.

The dual-speed nature of the Exec. Partner is a handy feature. All you have to do to change speed is press Ctrl-Alt-Plus (on the numeric keypad). An indicator light on the keyboard informs you of the speed at which the machine is running. I found it useful to compile programs at high speed and execute them at low speed to find bugs.

Also, in games such as the submarine simulation game Gato, you can cruise for long distances under high speed and then slow down to low speed when situations warrant it.

MEMORY

The Exec. Partner comes with 256K bytes of memory configured as 32 64K-bit RAM chips. To expand the system to 640K bytes of memory, you must remove 16 of the chips from their sockets and replace them with 256K-bit chips. Also, the configuration of a DIP switch inside the machine must be changed. This switch bank has switches for configuring 8087-2 coprocessor and hard disk in addition to memory expansion. (Access to the memory chips and DIP switch is via a removable panel on the underside of the machine).

Two other handy features of the Exec. Partner are an internal clock/calendar that is powered by its own rechargeable battery, and a socket for an optional 8087-2 math coprocessor to speed up mathematical calculations.

DISK STORAGE

There are two configurations available for the Exec. Partner. The first has two 360K-byte floppy-disk drives. The second, which should be available by the

(continued)

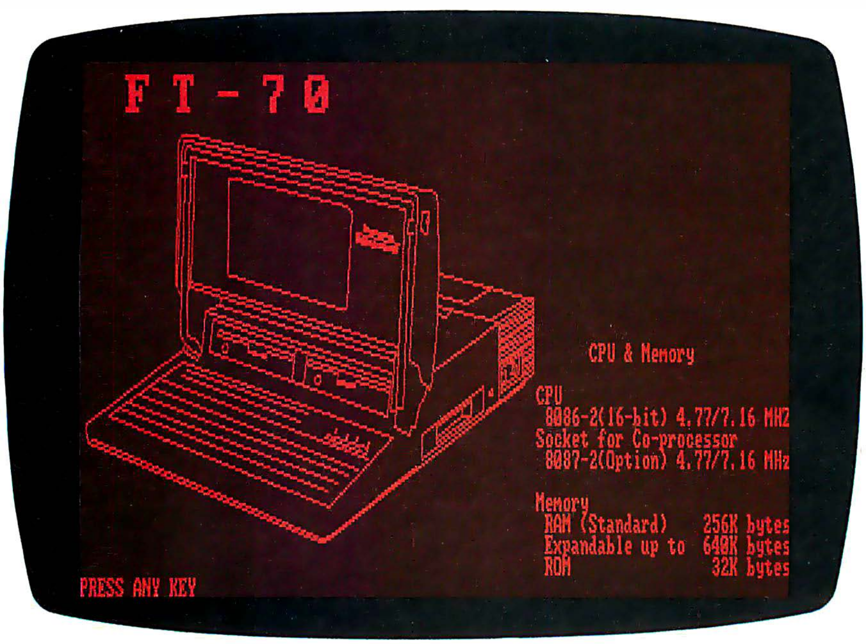


Photo 1: *The Panasonic Exec. Partner gas-plasma display panel.*

AT A GLANCE

Name
Panasonic Exec. Partner

Company
Panasonic Industrial Company
One Panasonic Way
Secaucus, NJ 07094
(800) 447-4700
(201) 348-7000

Size
21.7 by 16 by 5.3 inches
28 pounds

Components
Processor: 8086-2, 4.77/7.16-MHz clock speed
Memory: 256K bytes (optional 640K bytes)
Mass storage: Two 360K-byte floppy disks
Display: Gas-plasma display; 80-column by 25-line text; 640- by 200-pixel graphics; 640 by 400 resolution in text mode
Keyboard: IBM PC-style; 83 keys; function keys arranged horizontally; four LEDs
Power: 120 or 220 volts AC
Expansion: One short IBM PC-style expansion slot; connector for future expansion box.
Interfaces: One serial and one parallel port

Printer
Internal thermal-transfer printer; requires special paper; Epson-compatible

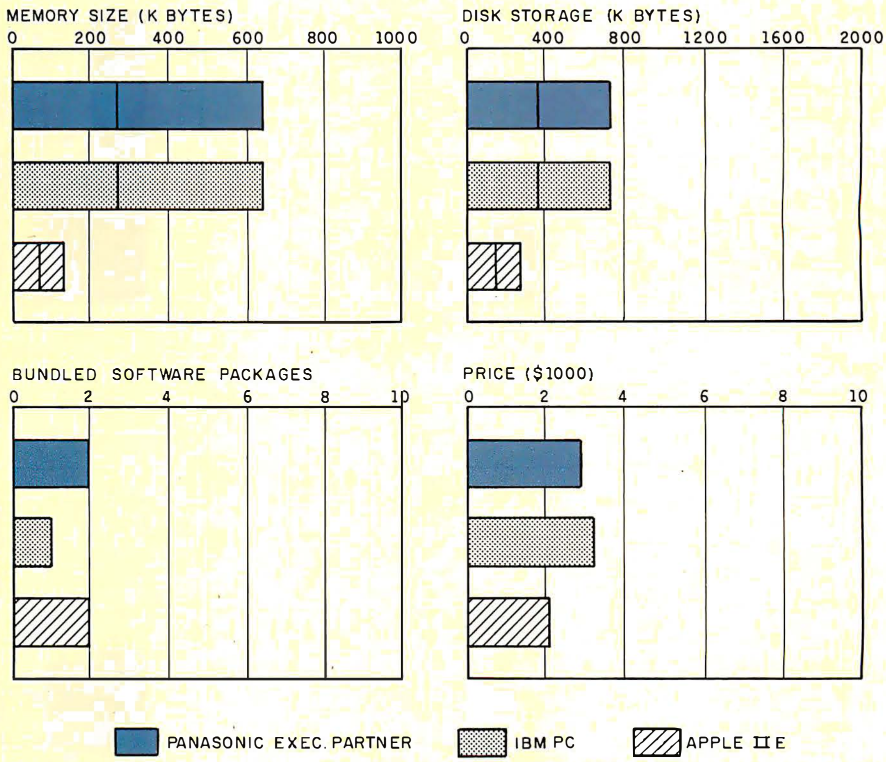
Software
MS-DOS, version 2.11
Microsoft BASIC

Options
10-megabyte hard-disk drive (replaces one floppy-disk drive)

Documentation
MS-DOS manual, BASIC manual, Quick Reference Guide

Price
Two floppy-disk drives: $2595
10-megabyte drive, one floppy-disk drive: $3795



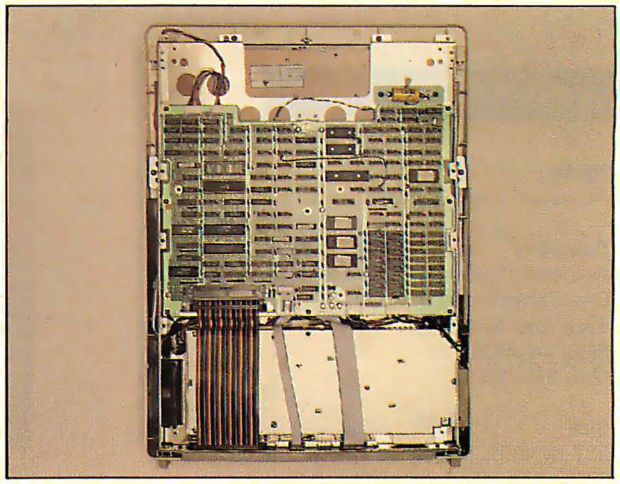


The Memory Size graph shows the standard and optional memory available for the three computers under comparison. The Disk Storage graph shows the capacity of the Panasonic Exec. Partner in comparison with each of the other computers.

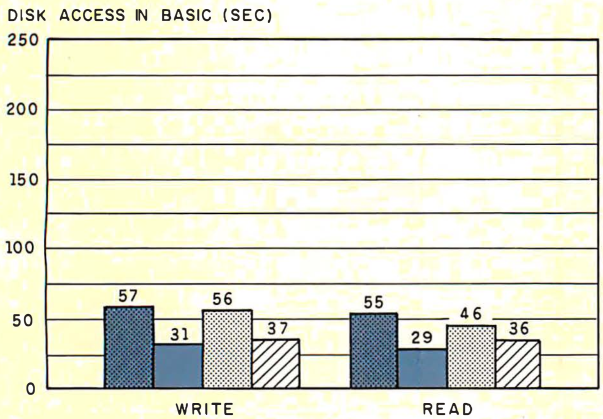
The Bundled Software Packages graph shows the number of software packages included with each system. The Price graph shows the list price of a system with two high-capacity floppy-disk drives, a printer port and serial port, 256K bytes of memory (64K bytes for 8-bit systems), and a monochrome monitor (the Exec. Partner has a built-in neon gas-plasma display). Price includes the standard operating system and BASIC interpreter for each system. Note that the Exec. Partner can display monochrome but not color graphics.

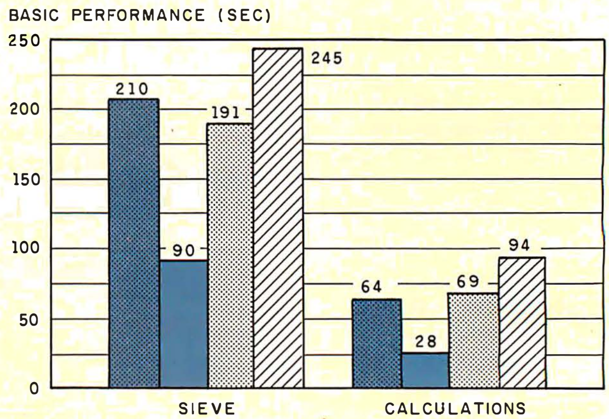


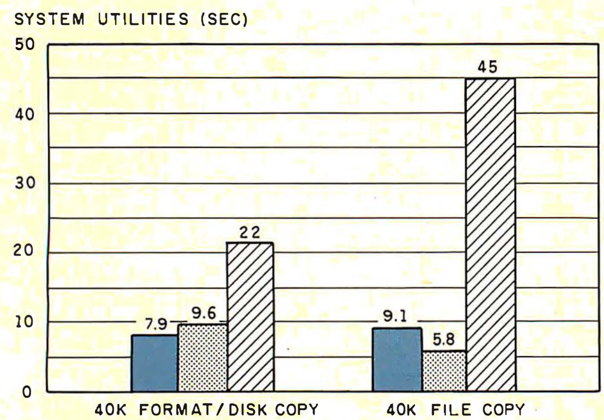
The back of the Exec. Partner showing, from left to right: power plug receptacle, parallel port, serial port, and expansion connector.

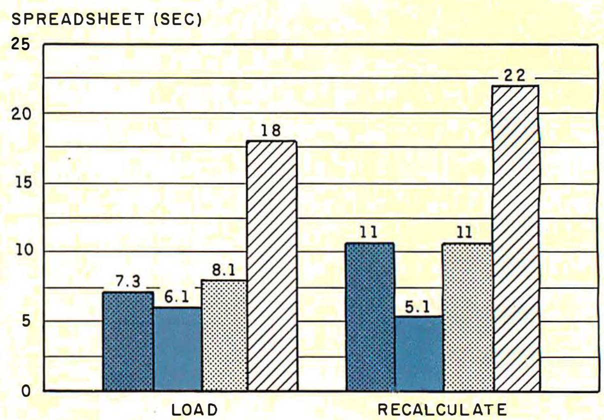


Clockwise from bottom to top: the Exec. Partner's power supply with cooling fan, ribbon cable to expansion connector, and the motherboard.









PANASONIC EXEC. PARTNER (LOW) | IBM PC
PANASONIC EXEC. PARTNER (HIGH) | APPLE II E

The Disk Access in BASIC benchmark writes and reads a 64K-byte sequential text file to a blank floppy disk. (For program listings, see June 1984 BYTE, page 327, and October 1984, page 33.) The Sieve results show how long it takes to run one iteration of the Sieve of Eratosthenes prime-number benchmark. The Calculations benchmark times 10,000 multiply and divide operations. The System Utilities benchmark formats a disk and copies a 40K-byte file to it. The Spreadsheet benchmark loads and recalculates a 25- by 25-cell spreadsheet where each cell equals 1.001 times the cell to its left. The tests for the Exec. Partner used BASIC 2.0. The tests for the Apple IIe used ProDOS. The IBM PC was tested with PC-DOS 2.0 and BASICA. The Exec. Partner was tested in both high-speed and low-speed mode for comparison to the IBM PC. The Format and File Copy tests were not affected by the change of processor speed.

time you read this, has one 360K-byte floppy disk and one 10-megabyte hard disk.

The system I used was the dual floppy-disk configuration. The floppy-disk drives on the Exec. Partner are somewhat noisy, and the disk-drive doors are a little hard to use. Sometimes they are hard to close completely. In addition, when you remove a disk from the drive, the drive motor continues spinning for about four seconds after you open the drive door.

I was disappointed by the presence of a warning sticker in the documentation stating that you should not put a disk into the drive before powering up the system.

INTERFACES

Sometime in the future, perhaps IBM, Apple, and Compaq may include serial and parallel ports with their computers. Until that time, companies such as Panasonic will continue to distinguish themselves by including such ports as standard equipment.

The Exec. Partner's serial port seems to work well with my 1200-bps modem. Likewise, the parallel port works well with my old Star Micronics Gemini printer. This printer port is actually the second parallel port on the machine. The first is used by the internal printer. You can alternate between the two simply by pressing Ctrl-Alt-PrtSc.

The Panasonic machine also comes with an expansion bus connector. At some point in the future, Panasonic says it will offer an expansion box that uses this connector. This expansion box would presumably have a number of IBM PC-compatible slots to allow you to use various expansion cards.

For internal expansion, the Panasonic contains a slot for a short IBM PC-style expansion card. Note that this card has to be shorter than 6 inches. The main use for this slot will probably be an internal modem. Also, some manufacturers have announced short cards for RGB color displays, which may be useful.

All connectors on the Exec. Partner have attached plastic lids to cover them when not in use.

PRINTER

The trademark of Panasonic microcomputers seems to be the internal printer. The older Sr. Partner included a small thermal printer with a roll of thermal paper. The new Exec. Partner appears to go one step further: It includes a thermal-transfer printer.

Although more technologically advanced, this printer lacks some of the advantages of the older thermal printer. Like the older printer, the new thermal-transfer printer can print on a roll of thermal paper. Unfortunately, you cannot store the roll inside the computer; you must carry it separately.

Before printing, you must set up the roll of paper on a spindle that attaches to the back of the computer.

The new printer has two modes: correspondence quality (or thermal transfer), which prints at a nominal rate of 30 characters per second; and draft quality (thermal, 60 characters per second). In addition, there is a switch for light, bold, or dark printing. Thus, you have a theoretical choice of six styles. Your practical choice is much smaller, and though the print quality is better than that of the Sr. Partner, you will probably not want to do much formal printing on this printer.

The older printer was quiet and very compatible with the IBM Graphics Printer. The new one is quiet when printing a line, but before each line, the print head snaps loudly against the paper. And at the end of each line, the print head snaps loudly again, away from the paper. As for compatibility, the printer does seem to respond to the common Epson commands (e.g.,

(continued)

Esc-E for emphasized, Esc-G for doublestrike). Like many printers, it has trouble with some of the IBM graphics characters, specifically the characters used to produce double-ruled boxes (characters 200–205).

The new printer also prints on single-sheet paper, but only on special smooth thermal-transfer paper. You can print on common xerographic paper, but this is not recommended, as the results are barely legible.

SOFTWARE

The Exec. Partner comes with only the MS-DOS operating system, version 2.11, and Microsoft BASIC.

Panasonic's version of MS-DOS seems fairly routine. The only significant enhancement seems to be the inclusion of a special driver for the internal clock/calendar. If you include the name of this driver in a CONFIG.SYS file on your system disk, the system will automatically check the clock/calendar for the date and time, without your having to enter the date and time manually.

Similarly, MS-BASIC is also fairly routine and is compatible, by and large, with the BASIC on the IBM PC. I was hoping that this version might have some ability to directly access the 640 by 400 pixels on the display, but the highest resolution you can address is the standard 640 by 200 pixels of the IBM Color Graphics Adapter.

I did have a little trouble running the communications program PC-Talk III, which is written in BASIC. Strangely, the trouble seemed to clear up when I switched the processor to fast mode.

In terms of speed, the benchmarks I did showed that the Panasonic BASIC is approximately as fast as the IBM PC's. When the Exec. Partner is in high-speed mode, however, this BASIC is about twice as fast as that of the IBM PC.

COMPATIBILITY

With the above partial exception for PC-Talk III, the Exec. Partner ran every IBM PC software program I tested. These included Lotus 1-2-3, Multiplan, WordStar, XyWrite II, SideKick, and SuperKey. The only incompatibilities I noticed were the previously mentioned problem that the printer had with certain graphics characters and a problem that the display had with certain text styles.

MANUALS

The Exec. Partner comes with two manuals and a 20-page quick-reference guide. The MS-DOS manual comes in the usual IBM PC-style binder and slipcase. In addition to notes on the operating system, this manual also includes some notes on the Panasonic hardware.

The BASIC manual is 6 inches by 9 inches, perfect-bound. The pages are the same size as those in the MS-DOS binder, but without the bulky binder. Unless Panasonic issues updates for their BASIC, the bulky binder won't be missed.

SUMMARY

All in all, the Panasonic Exec. Partner is an acceptable computer. Its most prominent feature is its gas-plasma display. It is very easy on the eyes, but it has a slight problem handling multicolor text.

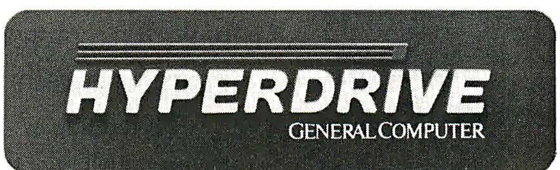
Another good feature is its keyboard-selectable dual-speed processor, whose high speed is about twice as fast as the IBM PC's processor.

On the other hand, the printer seems of limited utility, and in many cases merely provides extra weight for the system. Finally, the short expansion slot hampers your ability to expand the system without the (as yet unavailable) expansion box.

If I were Panasonic, I would make some minor changes. First, I would make the printer optional. Second, I would make the gas-plasma display more compatible with the IBM monochrome display. And finally, I would provide an RGB connector and a full-size expansion slot.

Even without these changes, however, the Exec. Partner is a useful machine, especially for people who are tired of looking at green-phosphor screens. ■

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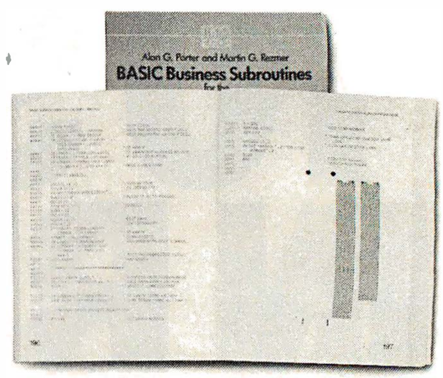
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KAMAS

An outline processor and programming language

BY ALBERT S. WOODHULL

KAMAS, billed as a "Knowledge and Mind Amplification System," is one of a class of programs sometimes called idea processors or, less grandiosely, outline processors. But for $99.95, KAMAS also includes a language in which you can write batch-processing scripts for your word processor or, using more primitive elements of the language, programs to handle any application. [*Editor's note*: KAMASOFT *has produced a version of* KAMAS *called* Out-Think *for people who don't want or need programming language capabilities* (*see page* 40).] In the KAMAS environment there always seems to be a command that will open up a whole world of other commands on a lower level.

In KAMAS, text is attached to a tree structure, which you create with an "outline editor." At the outline-editing level, you can manipulate and move around a document in a way that corresponds to the logical organization of the document. You enter and edit text in a part of KAMAS called a "leaf editor." The "leaves" you create are attached to the outline.

KAMAS's smartness about the organization of a document also makes it a powerful tool for retrieving information. Browsing through a file with an ordinary word processor, you can search many times for a word or phrase before you find the right part of a large document. With KAMAS, you can strip away the text and see the outline.

KAMAS is layered like an onion. The leaf and outline editors are only two layers. Below these screen-oriented levels is a level at which all the outline-processing commands are available in a form that lets you use KAMAS from a line-oriented terminal. From here, one option gives you access to an even lower level, where you can specify commands and their arguments either in command lines or as text in a file—at this level you are programming. Below this are two more programming levels that constitute a general-purpose, extensible, threaded interpretive language akin to FORTH, STOIC, or Magic/L.

My interest in KAMAS is as a writer. I find it easiest to generate a flow of words when I write as fast as I can, as if I were talking about the subject. I may approach different parts of a topic this way, generating several large and unconnected blocks of text. Organizing the final paper is a major task, as difficult as generating the text. Word processors are more important to me (a horrible typist) than they are to people I know who can type fast and flawlessly on a typewriter. For analogous reasons, KAMAS interests me as a tool for use in the organizational phase of the writing process.

INSTALLING KAMAS

The KAMAS documentation package contains a 55-page booklet of installation instructions. As you would hope from a product that is supposed to help you organize knowledge, this manual is well organized, and the installation instructions are easy to follow.

KAMAS requires a Z80 microprocessor with 64K bytes of RAM, the CP/M operating system, at least one disk drive with 126K bytes of storage space, and a total of at least 200K bytes of disk space. The required 126K-byte disk capacity is calculated to make an Apple II with a Z80 card adequate. I did much of my work with KAMAS using the more-or-less standard configuration of an Apple II with a 64K-byte RAM, a Microsoft Softcard running CP/M 2.2, two Apple Disk II drives, and an 80-column card from Advanced Logic Systems (ALS), the Smarterm II. I also used KAMAS with an ALS CP/M Card and CP/M Plus (CP/M 3.0). I did not have to reconfigure to use CP/M Plus; selection of "Apple II (Softcard CP/M)" in the configuration menu resulted in a KAMAS setup that worked equally well with either version of CP/M.

I did encounter problems configuring KAMAS to take advantage of a Synetix Flashcard RAM disk and a Taurus 8-inch floppy-disk drive. The software drivers for

(continued)

Albert S. Woodhull is associate professor of computer studies and biology at Hampshire College (School of Natural Science, Hampshire College, Amherst, MA 01002).

AT A GLANCE

Name
KAMAS

Type
Outline processor and programming language

Company
KAMASOFT Inc.
(formerly Compusophic Systems)
POB 5549
Aloha, OR 97007
(503) 649-3765

Requirements
CP/M 2.2 or later (Z80 required), 64K-byte RAM, 48K-byte CP/M TPA (see text), at least 200K bytes of disk storage, one floppy-disk drive with at least 126K bytes of storage, 80-column by 24-row ASCII terminal with direct cursor addressing; printer, I/O-mapped serial modem port recommended

Format
5¼- or 8-inch soft-sectored floppy-disk formats for most CP/M systems

Language
KAMAS, a proprietary language

Documentation
Three-volume user's guide, more than 600 pages; installation instructions; two reference cards

Price
KAMAS, $99.95
Utility Disk 1, $10 ($5 if purchased with KAMAS)

both of these were installed in the CP/M transient program area (TPA). The KAMAS documentation claims that a 48K-byte TPA is adequate, and I had slightly more than 48K bytes available with the RAM disk installed, but I could not make this configuration work. A call to KAMASOFT, the publisher of KAMAS, brought an admission that more memory is required than is stated in the documentation.

Fortunately, there is an option to install the RAM-disk driver software in the I/O configuration area provided within Microsoft's implementation of CP/M. I was still unable to use my 8-inch drive with KAMAS under this version of CP/M, however.

USING KAMAS

KAMAS uses various terms to describe its database structures. These terms are "topic," "key," "title," "subtitle," "stem," "branch," and "leaf."

The highest level in the structure is the topic. Each topic corresponds to a disk file. A topic consists of branches, and branches are made up of stems, the basic unit within a topic. Stems have three parts, one required and two optional. The required part of a stem is its key. KAMAS uses these keys to construct an index for searching. A key may have a subtitle, which clarifies its meaning, but the subtitle is not used in key searches. The combination of a key and a subtitle is called a title. The other optional part of a stem is a leaf, which can contain a moderately long block of text.

A topic has one stem at the topmost level, and any number of additional stems may be subordinate to this top stem. Subordinate stems are also called children, and the top stem is their parent. A child of one stem may be a parent to still more. From any particular parent stem, its children and their children and their children, to whatever level exists, all constitute a branch.

It's important to understand that titles and leaves are separate types of data that you can and must manipulate separately. Depending upon whether you are using the outline editor or the leaf editor, at any given moment you see on the screen either the titles, as in figure 1, or a leaf, a block of text that would accompany one of these titles.

When you invoke KAMAS from the CP/M prompt, you are asked to select an available topic. You then find yourself in the outline editor, with the topmost title and the titles on the next lower level displayed. In the outline editor the cursor is always on the current stem, of which only the title is visible, but pressing Return gives you a display of the associated leaf and moves you down to the next stem. You can expand any branch to see more detail, or you can collapse branches to hide details. Other commands let you move around in the topic and insert, delete, or change titles and subtitles. You can also move stems and branches to different places and change the hierarchical relationships between stems. When you leave the outline editor, you can enter either the leaf editor or the ROVE mode.

Within the leaf editor you can manipulate the text of the leaf, and you can also look at the portions of the

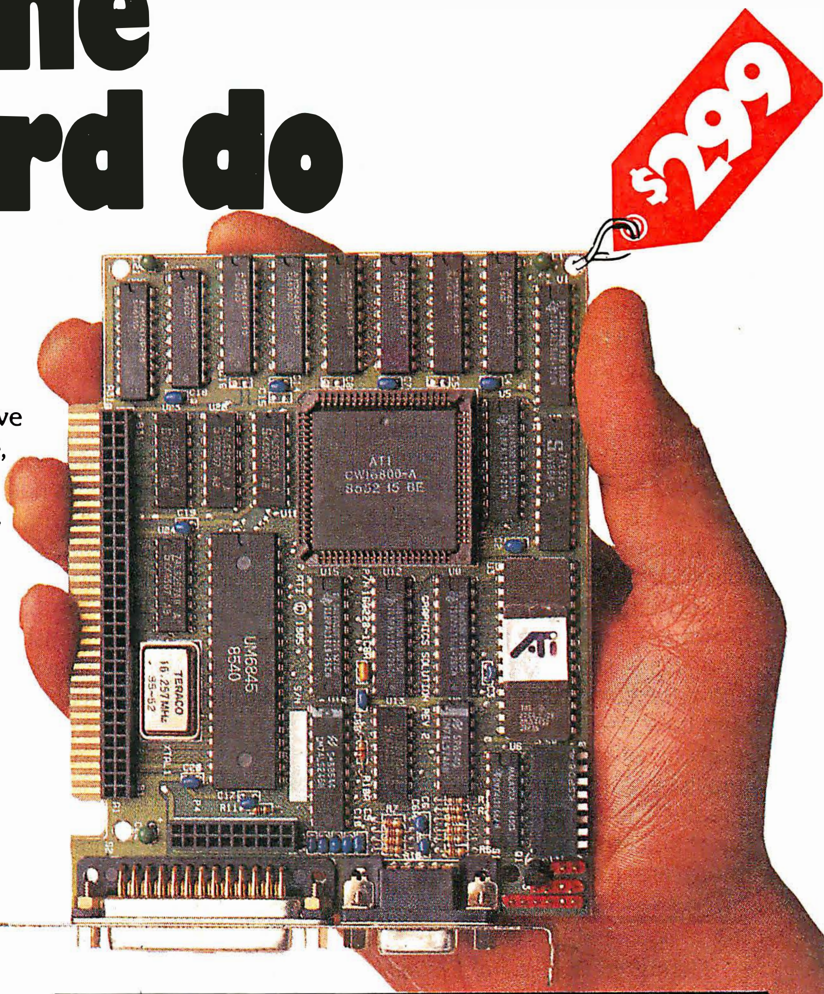
(continued)

```
TOPIC—a database of text
  BRANCH—a part of a topic
    STEM—a single item in a topic
      TITLE—a part of a stem
        KEY—the required part of a title
        SUBTITLE—an optional part of a title
      LEAF—an optional part of a stem
```

Figure 1: *The structure of a KAMAS topic. This figure was generated by KAMAS. It includes the titles for a number of stems, without the leaves of text associated with each title.*

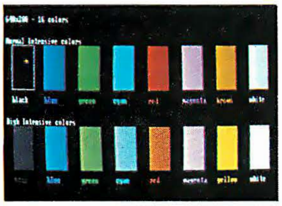
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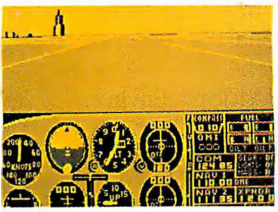




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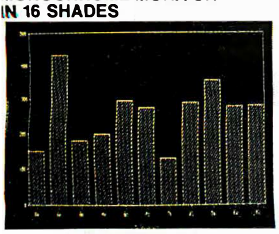
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IBM Compatible Color/Graphics	✓	✓		✓
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Flicker-Free Scrolling in All Modes	✓	✓	✓	
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outline close to the leaf being edited. You cannot alter the outline structure from within the leaf editor, except for splitting a leaf at the current cursor position, which creates a new leaf containing all the text following the cursor.

The leaf editor can be configured to look like either an EMACS-style or a WordStar-style editor. This decision cannot be changed later except by configuring anew from a copy of the distribution disk.

I chose the EMACS-style editor. This is not a full-function word processor. The usual single-key commands to move the cursor up and down by lines and back and forth by characters are present, but missing is the ability to move by words, sentences, and paragraphs. The only way to delete text is by characters, or by marking blocks; there are no commands to delete whole words. The limited ways of moving the cursor can make marking text for deleting or moving a tedious job.

One essential feature is available: The editor holds deleted text in a buffer and lets you reinsert it, either in the same leaf or in a different one, even in a different file.

The leaf editor does not know about justification or line lengths less than the full-screen width. Thus, what you see on the screen is not necessarily what you will get on paper.

When you have finished editing a leaf you have to go back to the outline editor to do anything else. From here you can select a new leaf to edit, exit from KAMAS, or go down a level to ROVE mode.

ROVE is a command-driven mode. Entering ? at any time brings a list of options available. All commands have secondary options, some have tertiary options; the program prompts you for each. Although most ROVE functions can also be handled by the outline editor, the main reason for retaining this level is to provide a way to interact with KAMAS without a fast CRT terminal—for example, from a remote terminal with a low data-transmission rate.

Listing 1: *The Sieve of Eratosthenes program in the* KAMAS *programming language.*

```
; Sieve of Eratosthenes
LANG SYS
':BARRAY : BUILDS ALLOT TORUN WO+ .
8190 'SIZE :WOCON
SIZE 'FLAGS :BARRAY
'SIEVE :
    " 1 iteration " STOUT
    0 FLAGS SIZE 1 MFILL
    0
    SIZE LOOPS
         IWO FLAGS FETB
         IFSO
              IWO DUPW WO+ 3 WO+ DUPW IWO WO+
              LOOP DUPW SIZE WO>
              UNTILT 0 OVERW FLAGS STOB OVERW WO+
              .LOOP
              DROPD WO1+
         .IFSO
    .LOOPS
    WOOUT " primes" STOUT .
```

Table 1: KAMAS *compared with other languages in running the Sieve of Eratosthenes benchmark. Times are in seconds.*

	CP/M 2.2 (2-MHz Z80)	CP/M Plus (6-MHz Z80)
FIG-FORTH	16.4	6.6
Magic/L	22.7	9.2
KAMAS	28.6	10.9
MBASIC	365.2	211.9

PROGRAMMING WITH KAMAS

The top level at which you can start programming is called the Expanded Topic Environment. Many of the commands available at this level are noninteractive forms of ROVE commands. Arguments are specified in a FORTH-like postfix notation. You can write a script of such commands, that is to say, a program. Thus, if a topic is to be output to a printer with different portions formatted with different margins, this level allows you to program it as a batch job. Control structures for looping and conditional execution are available at this level.

Below the Expanded Topic Environment, the language looks like a perverse version of FORTH, with FORTH commands hiding under different names. There are important differences from FORTH, however: Control structures can be tested interactively, several data types are available, there is extensive error checking, and the implementation is different from FORTH (it uses direct, rather than indirect, threaded code). None of these changes justifies creation of a language of totally unfamiliar appearance. Alternatively, the language could have been designed to make it look familiar to a user of Pascal or C, as was done with Magic/L, another FORTH-derived language. [*Editor's note: See Michael W. Gilbert and Albert S. Woodhull's review of Magic/L in the November 1985 BYTE, page 337.*] Instead, KAMAS puts unnecessary obstacles in the way of the experienced programmer.

You may guess that I was not motivated to undertake an extensive programming project in order to evaluate KAMAS as a language. I tried out some of the examples in the user's

guide, and I ran a benchmark test using the Sieve of Eratosthenes. The KAMAS program is shown in listing 1; it is a modified version of a sample program from the user's guide.

Table 1 shows the results of a comparison of KAMAS with FIG-FORTH and Magic/L as well as Microsoft BASIC. KAMAS is definitely in the FORTH league.

SUPPORT

In addition to *The KAMAS Report* newsletter and telephone support, KAMASOFT provides good documentation and a vehicle for distribution of updates and applications through utility disks. Volume 0 of the user's manual is a 50-page guide to the outline and leaf editors. Volumes 1 and 2 completely describe the rest of the system. There are numerous examples as well as reference information describing all the commands available to the interactive user and the programmer. There is an index to volumes 1 and 2.

The review copy of KAMAS that I received included the KAMAS Utility Disk 1. The contents come from users as well as from KAMASOFT and have been placed in the public domain. Thus these contributions can be freely copied and distributed through bulletin boards.

Finding what you want on the disk can be confusing, however. Utilities, examples, and documentation text are not always where they are said to be. For instance, the installation manual says some programming examples have been moved from SYSTOPIC.TOP on the system disk to Utility Disk 2, but that disk apparently hasn't been released. As another example, Utility Disk 1 held only one topic file rather than the two that are described in the READ.ME file on the disk.

KAMAS PROBLEMS

Several things strike me as problems with KAMAS. To begin with, the console interaction needs improvement. KAMAS doesn't use cursor positioning well. The entire screen is often rewritten unnecessarily, for instance, when a paragraph in the bottom half of the screen is reformed or the end of a line is deleted. I'd like a status line to tell me where I am and show the size of the current leaf. There is also no way to have more than one window on a leaf being edited.

The worst console-interface problem is that typing can overrun the editor. This happens when a word that does not fit on a line is being moved to the beginning of the next line; a few characters or even whole words get lost on every line. If my system had an interrupt-driven keyboard input, there would be no problem, but a hardware solution isn't necessary. The

(continued)

software should give very high priority to sensing console input, even if it means letting the display get a little behind the input at times.

Another problem: Practical work requires easier transfer between KAMAS topic files and CP/M text files. You can transfer KAMAS data to CP/M text files but not vice versa, so giving KAMAS access to data in existing text files is complicated. A contributed utility program lets you copy a text file into a newly created topic file, either creating leaves with synthesized unique names or using commands embedded in the source text file to create an outline structure. The first method requires major editing of the new topic; the second method, major editing of the source text file. I would prefer a way to use a split-screen display to view a non-KAMAS text file, move a cursor around within it, and snip out little pieces to be inserted into a leaf being edited on the other half of the screen. This would be a powerful addition to KAMAS.

Style and Language

KAMAS has none of the blandness of software developed by a corporation; there is definitely an individual style detectable here. It is generally not my style—calling this a "Knowledge and Mind Amplification System" seems rather immodest, and I would never have titled a chapter in the documentation "Zen and the Art of Knowledge Processing."

In places, the use of language is more than just a question of taste. For example, one of the first things you see on the screen after invoking KAMAS from the CP/M prompt is the message that the program is "autojexing." Autojexing (automatic job execution) means interpreting from text in a leaf. Again, as soon as you make an error, you find yourself faced with the word "abend." An abend is an error (abnormal ending). Jargon like this is inexcusable, and it will intimidate users who speak only English.

The documentation is also marred by outright errors of language, such as using the plural "criteria" when meaning the singular "criterion." I think the audience for this product includes many who are concerned with precise communication. They will be turned off by such careless use of language.

Conclusion

Outline processing is a very powerful idea, and KAMAS provides an economical way for users of CP/M-80 systems to try it. KAMAS is a rarity in the current market, a new program released first for use on 8-bit processors. I used KAMAS to draft this review, except for final revisions, when the inability to move easily from leaf to leaf became a serious obstacle.

KAMAS can also process existing documents. It incorporates a language with high-level commands and operations well suited for such tasks, and extensions can be programmed. The KAMAS language is fast and powerful and provides a good interactive programming environment. Learning to use it takes some effort (in my opinion, more than it should) even for FORTH users familiar with stack-oriented languages.

KAMAS has some rough edges. I encountered no serious bugs, but not all the parts of the program mesh smoothly. The documentation is extensive but has not caught up with the material being shipped on disk. The leaf editor is better than a line editor, but it's primitive compared to word processors like Mince or WordStar.

If you are limited to CP/M-80 and your job involves organizing information, you should consider KAMAS. At the time of this writing, I don't know of any other programs that compete with KAMAS in the 8-bit world. As it comes out of the box, KAMAS is ready to use as a tool for creating organized documents; it is also a useful high-level programming environment for creating other programs to process textual data.

As software packages go, KAMAS is relatively inexpensive. Outline processing is the major reason to consider buying it, but the presence of a fast general-purpose programming language might add to its value for you. ■

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Professional Debug Facility and Advanced Fullscreen Debug

Two more debuggers for PC-DOS

BY JACK C. CARDEN

PC-DOS-compatible debuggers today come in all shapes and sizes. One recent addition is Advanced Fullscreen Debug (AFD), distributed by Puttkammer Software and Microcomputertechnic of West Germany. Another is Professional Debug Facility, distributed by IBM Corporation of Boca Raton, Florida. Professional Debug Facility consists of a Resident Debug Tool (RDT), a Disk Repair (DR) utility, and an NMI (nonmaskable interrupt) card for use in activating RDT.

The outward similarities of the two debugging aids led to this comparative review. Both packages are software-based debuggers that operate at the machine-instruction level and implement breakpoints by replacing a byte of memory with an INT 3 instruction. Both present full screen displays containing multiple windows of information about the program under test (see photos 1 and 2). Both reroute the NMI 2 to allow the use of an external push button to gain control after a runaway software path has missed all breakpoints. The IBM package provides an NMI card with an externally mounted push button, while the AFD user's manual provides instruction for constructing an NMI push button. Both also provide special key sequences to bring up the resident debugger from the background using a keyboard interrupt.

EXPECTED FEATURES

Both programs contain most of the features usually available in off-the-shelf debuggers. Each permits you to compare two areas of memory, copy a block of memory to another area of memory, or search memory for a particular series of bytes. Both allow you to alter the contents of memory or register by moving the cursor to the correct spot on the screen and typing over the data with new data. Each of the debuggers allows program execution to begin at a specified address with specified breakpoints. Most breakpoints are sticky; that is, the breakpoints remain in place until you remove them. Any breakpoint can be disabled and left in place. Each program provides the ability to do byte I/O, and both support the output of information to a printer. Both programs use the trap flag in the processor for single-step execution. Each allows any area of memory to be treated, displayed, and modified as instructions or data, either hexadecimal or ASCII. RDT also supports EBCDIC character interpretation, but then that should not come as a surprise to IBM users.

Both debuggers support the use of a color and monochrome display at the same time, and can direct output to a selected display, leaving the other display free for the program under test to use. Both programs also allow the use of a screen-save buffer, which can be useful if you are like me and don't happen to have two display systems. RDT requires that during setup you specify whether the screen-save buffer of 4K bytes should be reserved.

SURPRISING FEATURES

AFD provides a procedure-step function key as well as a single-step function key. The procedure step sets a breakpoint on the instruction following the CALL or INT instruction within a routine.

AFD provides two extra registers, called fixed segment (FS) and help segment (HS). The FS and HS registers may be automatically updated following a compare command for use in displaying the mismatching areas of memory. The HS register is updated following a successful search command, for use in displaying the start of the located string in window area 2. It may also be modified to hold a segment address when AFD is requested to display a fixed area of memory. These registers may be set to any desired 16-bit value and used in expressions as any of the machine registers would be used.

In addition to 18 breakpoint registers per screen, RDT provides 40 extra 20-bit regis-

(continued)

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ters for use in holding values of interest to the programmer and can be used in expressions as desired. One of these values, IL, represents the instruction length of the current instruction. Following a search, the FX (find hexadecimal) register contains the address of the match or zero if no match was found. OP represents the instruction parameter address and probably stands for operand.

RDT also supports the math coprocessor by displaying the state of the coprocessor. RDT can optionally handle any exception interrupts from the coprocessor.

AFD supports the additional Intel 80286 instructions by permitting them to be assembled and disassembled. AFD assumes the real-address mode of operation on IBM PC ATs.

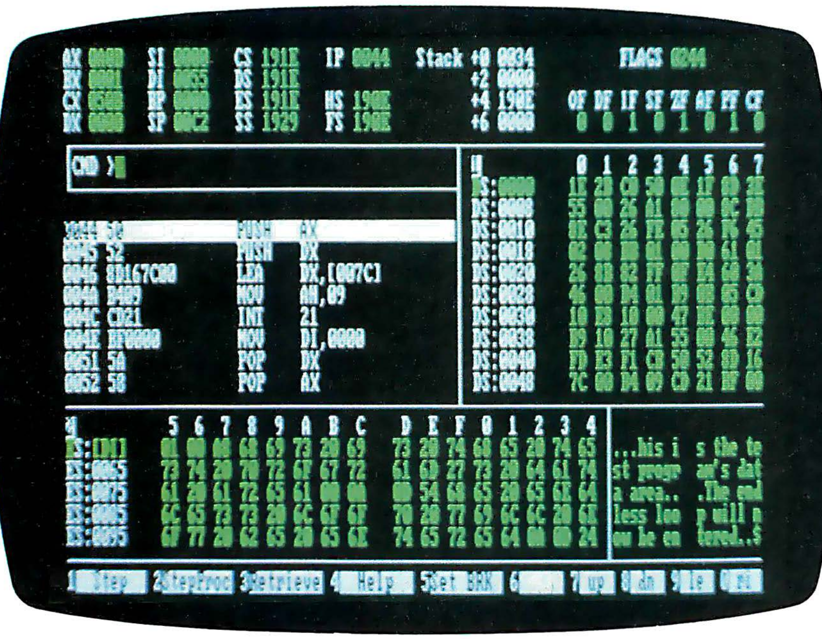


Photo 1: *The Advanced Fullscreen Debug main screen.*

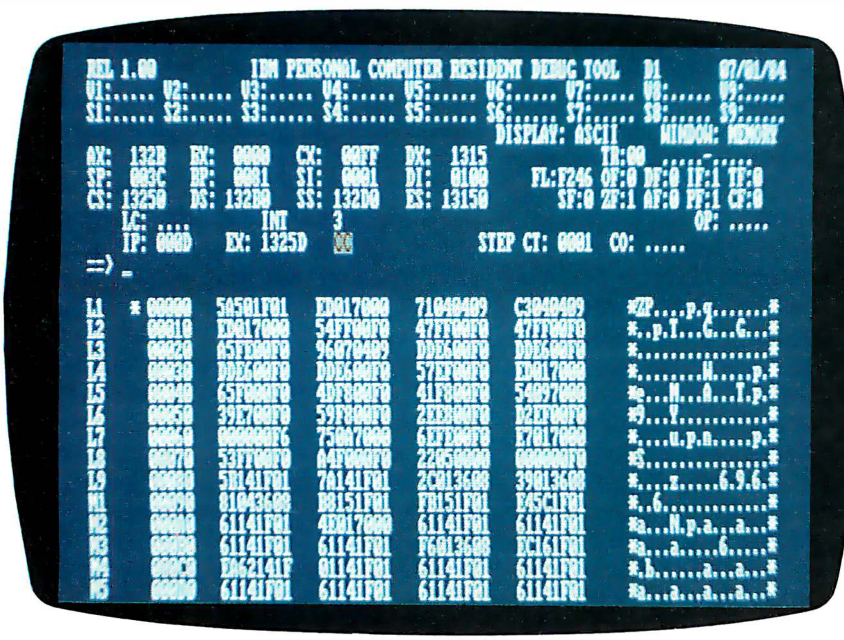


Photo 2: *The Resident Debug Tool memory window display.*

Customization

Both programs allow customization of displayed data, but RDT goes a step further. RDT allows up to nine different screen definitions to coexist for use with different areas of the program under test. If your program consists of seven different modules, you can set up seven screens to allow references to depths within a module to correspond to the listing you are using. Each screen has separate display parameters to uniquely generate each line within the bottom portion of the display and also has up to 18 unique breakpoints or internal variables. Internal variables allow easy reference to labels once the value is assigned. Theoretically, you can enable up to 162 breakpoints at one time. When a breakpoint is reached during execution, the screen containing the breakpoint definition, and thus the other related information, is displayed.

Disk-File I/O

RDT does not provide the ablity to save all this setup information to a disk file. In fact, it makes no provision for disk I/O on a file basis. Perhaps this is due to a philosophy of providing stand-alone operation as much as possible. Their justification might be that the NMI push button precludes the need to save setup information, since you can pass control to RDT regardless of the machine state. Perhaps the additional need to support disk-file I/O may be the real reason the ability to save setup information was omitted. RDT does provide commands to read and write disks using logical sector numbers, similar to the PC-DOS interrupt 25 and 26 type interfaces. And since PC-DOS is apparently not used for I/O, RDT might well be used to debug additions to

(continued)

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AT A GLANCE

Name	Advanced Fullscreen Debug version 1.00	Professional Debug Facility version 1.00
Type	IBM PC software debugger	IBM PC software debugger, plus disk-repair utility
Company	Puttkammer Software and Microcomputertechnic Nelkenstr. 4 D7039 Weil-3 West Germany 0049/7031-52256	IBM Corporation POB 1328 Boca Raton, FL 33433 (800) 426-2468
Hardware Required	IBM PC, PC XT, or PC AT in real-address mode under PC-DOS 3.0, PC-DOS 2.0 or above (except PC AT), 128K bytes of memory, one disk drive, 80-column display with adapter; supports both monochrome and color display as well as printer	IBM PC, PC XT, or Portable PC, 128K bytes of memory, one disk drive, 80-column display with adapter, PC-DOS; supports both monochrome and color display, printer, math coprocessor
Documentation	89-page manual with plastic comb binding	280-page manual in loose-leaf binder with reference card
Price	$110 plus $5 shipping	$150 including NMI card

the operating system.

AFD, on the other hand, makes no provision for disk I/O without the use of the PC-DOS file system. The load and write commands appear similar to those of the PC-DOS Debug. I found the commands to save breakpoints to and restore breakpoints from a disk file useful, since I usually require several passes through a program to complete the debug process and welcome any relief from having to enter the same data again and again. You can also create command sequences and save them in disk files for use later.

Disk-File Command Execution

AFD comes with a demonstration batch file to load and execute the included test program. The batch file invokes AFD with the command-line option to execute a recorded command file. This file contains the commands to load the test program, read the breakpoint setting file, and start the test program with an immediate breakpoint set at offset 44 hexadecimal. As the commands from the file are executed, each is displayed on the input area of the screen. This eliminates the need to type a series of commands to reach a particular point in the program where you wish to begin testing. In some cases, it would be easy to simulate missing procedures by breakpointing at the procedure call, modifying the appropriate registers or data, and resuming execution following the procedure call all automatically from a command file stored on disk.

Conditional Breakpoints

The term "breakpoint" traditionally has meant a stopping point where the operator can regain control of the program under test. AFD extends the flexibility of breakpoints with the use of action fields, count fields, and real-time tests of conditions in the machine.

First of all, AFD allows the traditional stop to occur when a breakpoint is reached. Other options, however, include the ability to count occurrences of a breakpoint or to reset the occurrence counter and reactivate a list of other breakpoints. Alternately, the programmer may choose to start or stop the trace feature with the occurrence of a breakpoint.

Each AFD breakpoint has one of the above actions specified along with a condition field and count field. The count field defines how many times the breakpoint must be met with true conditions before the action is performed. A condition is either another *gating* breakpoint specified by number, or an equation or relation involving registers or memory. A gating breakpoint is true if the occurrence counter and count field of that breakpoint are equal. Equations (=) or relations (<, >) may specify an optional offset or mask value to be included in the test. All conditions are ANDed together to determine whether the occurrence count for a breakpoint should be incremented. Then the count is incremented, and if the occurrence count is equal to the count field, the action is taken. The combination of all three fields leads to some powerful options in AFD breakpoints.

Instruction Tracing

The trace feature of AFD is started or stopped via a breakpoint. The action field of the breakpoint specifies if interrupt-handling routines are to be omitted during the trace. The trace buffer is cleared automatically when any GO command is issued. The buffer will hold 100 instructions before beginning to wrap around and overwrite itself. When a stop breakpoint is reached, the word TRACE appears on the screen to call attention to the buffer if data has been collected.

The trace activity of RDT is performed while stepping the program under test. RDT allows careful selection of the type of instruction and area of memory to be traced. For example, RDT allows the selection of only JUMP or CALL instructions above RDT and below the BIOS. Since the step count can be adjusted under RDT to allow many instructions to be executed, and other options allow the programmer to stop on trace conditions, this is a powerful feature of the RDT program. RDT allows the trace

(continued)

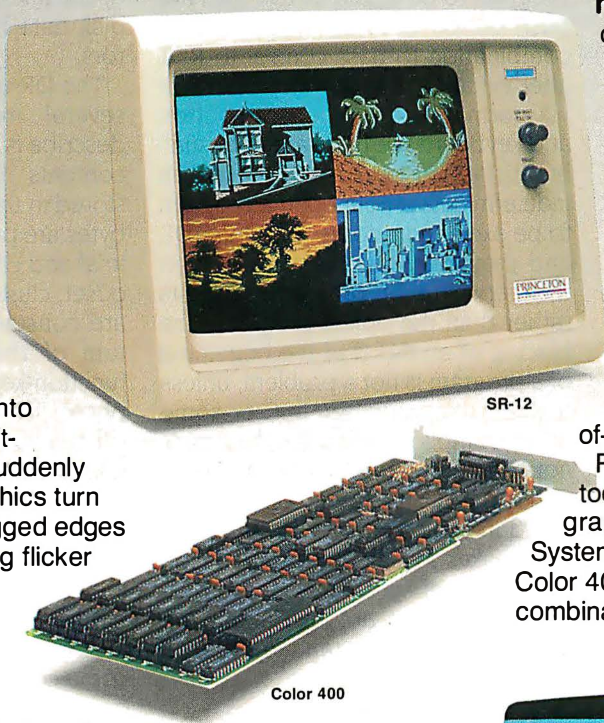
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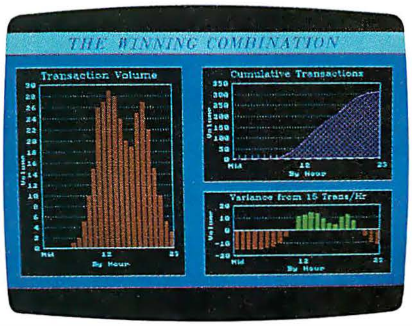
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buffer size to be expanded and execution to optionally stop if the buffer becomes full. The default buffer size will hold 32 instructions.

MEMORY REQUIREMENTS

All this power in conditional breakpoint processing and disk-file command execution is not without a price. The PC-DOS Debug program requires about 12K bytes of main memory. RDT requires about 40K bytes plus the optional 4K-byte screen buffer. AFD requires just over 64K bytes, in addition to PC-DOS requirements. In my system, under PC-DOS 2.1, with the default of two disk buffers, the object program was loaded starting at paragraph 1126 hexadecimal under RDT (using the screen-save buffer) and at 1627 hexadecimal under AFD. For AFD users, this means that about 90K bytes have been used prior to loading any application, so in a 128K-byte system, only 38K bytes remain for your development.

MISSING FEATURES

A couple of features that are present in the Debug program provided with PC-DOS that are not included in RDT are the assembly-language input and load-file functions. Personally, I have never used the assemble command except to patch, and I believe that the practice of patching programs should have stopped when instructions began to have different byte lengths.

Since there is no load command in RDT, you must either include an INT 3 instruction at the beginning of each program to be tested or use the NMI push button or Shift-PrtSc keyboard combination to pass control to RDT after initiating the program under test via normal means. The push-button and keyboard methods are not usually satisfactory, because they allow an indeterminate amount of the program to be executed prior to entering RDT, and they often interrupt PC-DOS in the servicing of program requests rather than the object program. The placing of an INT 3 at the beginning of a program is not a problem, unless the program is written in C or some other compiled language that does not have assembly-language instructions. The requirement of having an INT 3 in the code to pass control to RDT makes it difficult to look at the operation of programs for which source code is not available. The adoption of a new standard, that of placing an INT 3 at the beginning of initialization code in a high-level-language library, may be necessary to support the nonloading debugger.

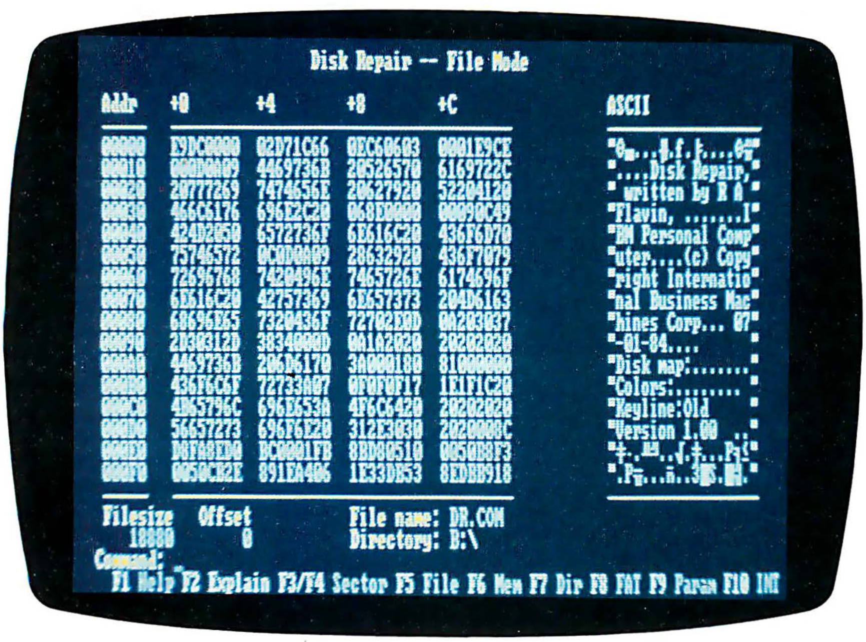


Photo 3: *The Disk Repair utility's File mode screen.*

DISK REPAIR UTILITY

The Disk Repair (DR) utility included with the Professional Debug Facility may well be worth the purchase price of the package, if you need to access disk data by physical or logical sectors.

The DR utility is able to operate in several modes. The simplest to describe is the File mode wherein the contents of a file are presented as stored in the file. On each screen, 256 bytes are presented, both in hexadecimal and character form. The file size, offset, cluster, filename, and directory are constantly displayed at the bottom of the screen along with the function-key definitions as shown in photo 3.

The F1 key displays the main menu where one of six different disk-repair modes, Parameter mode, or Interrupt/Call mode can be selected. The F2 key provides an explanation of the messages and fields when using each mode. This is the most useful help facility I have ever seen. If you become confused as to what is about to occur, simply pressing F2 will provide an intelligent explanation of the mode you have selected or the implications of modifying the data under the cursor.

One of the six disk-repair modes allows access in BIOS Sector mode, where drives, cylinders, heads, and sectors are known to exist. Another mode is the DOS Sector mode where only drives and logical sectors exist. File mode provides controlled access to an existing file, by name and offset. Memory mode allows access to internal memory. File Allocation Table (FAT) mode displays the data contained in the FAT on disk.

Directory mode displays the data in the directory portion of the disk interpreted for the user. While in this mode, you can press F3 to bring up a selected file in BIOS Sector mode, F4 to display it in DOS Sector mode, F5 to examine the file in File mode,

or F8 to see the clusters allocated to the file. Subdirectories are supported as well.

Parameter mode displays information concerning the format of the selected drive, allowing some examination of a non-DOS-formatted disk. Interrupt/Call mode allows controlled use of DOS and BIOS interrupts and calls to subroutines already in memory.

USABILITY

The RDT and DR programs of the Professional Debug Facility were easy to learn to use, quick to respond, and, except for having to remember the command set, can be operated with a 5-minute training session. The help screen of RDT only lists the myriad of two-letter mnemonics that make up the command set of RDT. The reference card is a must for the first few hours with RDT, but DR is so easy to use that the only reason to read the manual is for the great examples of how to restore an erased file.

AFD is a powerful package. To fully utilize all the capabilities of the conditional breakpoint facility would require a rather complicated problem. The program was solid in general, but several little items marred my overall impression of this program. There were slight inconsistencies in the way the cursor keys worked. The combination of some function keys and some cursor keys was confusing even after using the program quite a bit.

The program would not work properly with my Tecmar Graphics Master board unless I used a color display, because the AFD program directly modifies video RAM. This undesirable programming practice points out all too clearly the lack of compatibility with the IBM monochrome-display adapter provided by the Tecmar board. AFD did work better on all other systems tested, including an IBM PC AT with color display, IBM PC XT with color display, IBM PC with monochrome display, and a Kaypro 16. The only problem I noticed on any other system was on the IBM PC with the monochrome system, where the system status messages and error messages failed to appear.

The conditional breakpoint field in AFD allows the use of a mask value in comparison with a register but does not accept an immediate operand for the second operand. This seems to be an overly restrictive rule, since it prevents testing individual bits.

DOCUMENTATION

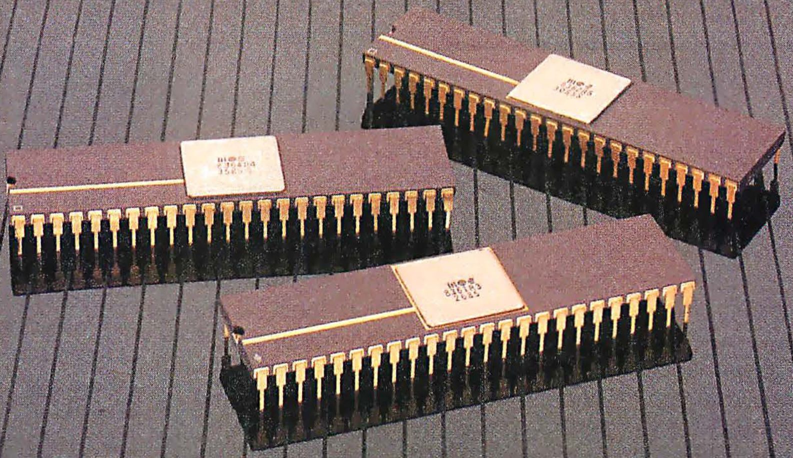
The AFD user's manual is not especially impressive. It is obviously written by someone whose natural language is not English, which makes it hard to follow at times. For example, "This function key allows to retrieve the last entered commands." The lack of examples makes the learning process a little intimidating. And there is no index, which makes the manual even less useful.

The Professional Debug Facility, however, comes in the standard three-ring loose-leaf binder with the polished look that you expect from IBM. The manual is nicely laid out, with a useful index and reference card, and enough tutorial to allow even the novice assembly-language programmer to feel comfortable with what is about to happen. The completeness is demonstrated by the inclusion of the "RDT Messages" section detailing most, if not literally all, possible responses from RDT.

CONCLUSIONS

I now understand why the word advanced was used in the title of the West German software distributed as AFD or Advanced Fullscreen Debug. I have only begun to appreciate the power and flexibility after several weeks of use. With a little more polish and a more useful manual, AFD can certainly hold its own in the American marketplace.

The Professional Debug Facility, containing the Resident Debug Tool, Disk Repair, and the NMI card for use with the Resident Debug Tool, is distributed as a package by IBM. This package is probably worth the purchase price for either of the software products for people involved in serious software development. ■



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S·O·F·T·W·A·R·E R·E·V·I·E·W

*micro*TSP

A flexible, user-friendly regression package for the IBM PC

BY PAUL DAVENPORT

The program microTSP is a microcomputer version of the very successful mainframe program Time Series Processor (TSP, from TSP International, Stanford, California). Both programs specialize in time-series regressions of the kind done by economists and other social scientists. (For information on time-series regressions, see the "Time Series in Statistical Analysis" text box on page 262.) The microTSP program offers a surprising degree of both power and ease of use, although some of its features require better documentation than the current manual provides. Version 4.1 of microTSP, released in 1984, has a number of improvements over version 4.0. Version 4.1 comes with two disks, one of which drives the 8087 mathematics coprocessor; either disk can be traded for a second copy of the other.

The program microTSP runs on the IBM Personal Computer and compatibles; it requires two disk drives, 256K bytes of RAM, and PC-DOS. You access microTSP from DOS simply by typing TSP. The time-series orientation of the program is immediately evident. Operations begin with the creation of a work file, which demands that you define the periodicity of the data (annual, quarterly, or monthly) and the start and end dates; undated data is also an option. The program is quite flexible. It is easy to change the start and end dates at any time; moreover, a series that covers only a part of the full range has N.A. automatically assigned to missing data. Data can be entered by the keyboard and edited with a special data editor, which lets you move up and down a time series with ease to make corrections or add new observations.

STATISTICAL OPERATIONS

Once the data is ready, you may fit an ordinary least-squares LS regression as follows:

```
SMPL 47 84
LS  Inv  C  i  i(-1)  i(-2)  Q  Q(-1)
```

The regression covers the years set by the SMPL command (1947 to 1984, with annual data); LS means ordinary least squares. Investment (Inv) is the dependent variables; C is the constant term; the independent variables are the interest rate (i) and gross national product (Q), with terms for 1- and 2-year lags indicated by negative integers in parentheses. Two-stage least squares TSLS has a similar format, with the instruments placed after @ in the command:

```
TSLS  Inv  C  i  i(-1)  i(-2)  Q
Q(-1) @ MS  MS(-1)  X  X(-1)  T
```

The instruments are money supply MS, exports X, and time T, which are considered to be exogenous variables that, in part, determine the explanatory variables i and Q.

The output that appears on the screen and is printed includes the sample period and number of observations; the name, mean, and standard deviation of the dependent variable; a list of independent variables, with coeffecients, standard errors, *t*-statistics, and 2-tail significance tests of the *t*-statistics; and the various regression statistics: *R*-squared, adjusted *R*-squared, standard error, Durbin-Watson, Log likelihood, sum of the squared residuals, and the F-statistic.

With both LS and TSLS you can request a first-order Cochrane-Orcutt correction for serial correlation by adding AR(1) at the end of the list of dependent variables (before the @ in TSLS). Higher orders of serial correlation require changing the integer: AR(2), AR(3), and so on. Output now includes the rho coefficient (or coefficients) of serial correlation. You can specify the maximum number of iterations (the default is 20) and the convergence change in rho (the default is a change in rho of less than .005, at which point the iteration stops). To correct for a moving-average error specification, you put MA(1)—and MA(2), MA(3), etc., if appropriate—at the end of the list of independent variables.

(continued)

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The above should give you an idea of the simplicity of microTSP commands. The program also includes the estimation of polynomial distributed lags; seasonal adjustment and moving-average seasonals; a missing-data MD option, in which regressions are run on those observations with data for all series (if MD is not chosen, any missing data stops the regression); and autoregressive and moving-average models. The manual gives interesting economic and business applications for the various estimators.

SPEED OF COMPUTATIONS

One of the drawbacks of statistical software for microcomputers is that the computations generally take more time than on mainframes. To get an idea of the differences involved, I designed a simple series of computations and regressions that you can easily replicate. I compared the computational speed of microTSP, with and without the 8087 processor, to PEC (Program for Econometric Computation, IBM version 7.0), a mainframe statistical package used by graduate students at McGill University. I began by defining a variable t, where t is 1 for the first observation, then 2, 3, and so on. To compare computational speed, I wrote batch programs for microTSP and PEC, which computed up to 25 variables as functions of t, sine of t, and cosine of t, using the equations shown in figure 1. For each of the two microTSP configurations (with and without the 8087 processor) three batch programs were run: the first computed the first 5 variables in the list for 20 observations (t = 1 to 20), the second computed the first 10 variables for 50 observations, and the third computed all 25 variables for 200 observations. The time in seconds required in each case is shown in column 3, lines 1 to 6 of table 1.

Immediately after each batch program, and while the relevant variables were still in memory, an ordinary least-squares regression was computed, with Y as the dependent variable. The first regression had 4 explanatory variables (X1 to X4), the second had 9 explanatory variables (X1 to X9), and the third had 24 explanatory variables (X1 to X24). In each case the software was instructed to provide a constant term. The times required for the regressions are shown in column 4, lines 1 to 6. The sum of the times required for calculations and regressions is shown in column 5, lines 1 to 6.

Column 5, lines 7 to 9, of the table shows the time required to run a batch program in PEC, which does both the calculations and the regressions, including the time necessary to load the program and any "line wait," which occurs as the mainframe services many users at once. The mainframe is McGill University's Amdahl 5850 with a 5860 accelerator; the MVS/SP operating system is used. Actual time for the computations is less than a second in each case, so that

$$
\begin{aligned}
Y &= 1.01^{t} * (1 + .1 * \sin(t) + .1 * \cos(t) + .1 * \sin(t) * \cos(t)) \\
X1 &= t \\
X2 &= t^{2} \\
X3 &= .980^{t} * (1 + .1 * \sin(.5 * t)) \\
X4 &= .985^{t} * (1 + .1 * \cos(.6 * t)) \\
X5 &= .990^{t} * (1 + .1 * \sin(.7 * t)) \\
X6 &= .995^{t} * (1 + .1 * \cos(.8 * t)) \\
&\ldots \\
X15 &= 1.040^{t} * (1 + .1 * \sin(1.7 * t)) \\
X16 &= 1.045^{t} * (1 + .1 * \cos(1.8 * t)) \\
X17 &= (X1 * X2)^{(.5)} \\
X18 &= (X3 * X4)^{(.5)} \\
&\ldots \\
X24 &= (X15 * X16)^{(.5)}
\end{aligned}
$$

Figure 1: *The equations used for the table 1 benchmarks.*

Table 1: *Comparison of compilation times using microTSP without the 8087, microTSP with the 8087, and the PEC mainframe package.*

	Number of		Time Required in Seconds		
	Variables	Observations	Calculations	Regressions	Total
	(1)	(2)	(3)	(4)	(5)
A. microTSP					
1.	5	20	14	7	21
2.	10	50	35	10	45
3.	25	200	211	141	352
B. microTSP 8087					
4.	5	20	11	1	12
5.	10	50	25	2	27
6.	25	200	98	25	123
C. Mainframe PEC					
7.	5	20	*	*	4
8.	10	50	*	*	8
9.	25	200	*	*	9

Note: See the text for a description of the arithmetic calculations and the regressions. The total number of calculations is the product of the number of variables and the number of observations (100, 500, and 5000, for the three cases shown).

(continued)

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AT A GLANCE

Name
microTSP version 4.1

Company
Quantitative Micro Software
4521 Campus Dr.
Suite 336
Irvine, CA 92715
(714) 856-3368

Requirements
IBM PC or compatible, PC-DOS, two disk drives, 256K bytes RAM

Price
$595

it makes no measurable difference whether you run the calculations and regressions separately or in one batch program.

With regard to accuracy, there were no significant differences in any coefficients or summary statistics for the regressions between the microcomputer and mainframes packages. With 5 and 10 variables, microTSP agreed with the PEC coefficients and summary statistics to 4 or 5 decimal places; with 25 variables, the agreement reached to 3 or 4 decimal places. The microTSP results with the 8087 coprocessor were identical to those without the coprocessor.

BATCH OPERATIONS

Batch operations on microTSP are the equivalent of macros on spreadsheets—they both allow you to save a series of commands. Repetitive operations can often be done more simply with batch commands; you can leave the machine during the operations if they take a long time. The batch programs are similar to those in PC-DOS: the parameters in a batch program are indicated by a % followed by a single digit; a RUN statement names the program and then lists values for the batch parameters. Suppose you have operations to perform on 20 different manufacturing industries. Consider the batch program Regress (see listing 1). To run the program, call RUN with the name of the program and values for each batch parameter (%0, %1, etc.)

```
RUN REGRESS LS 1 A
```

In the Regress program, everywhere %0 appears, LS is substituted, and likewise for %1 and 1, and %2 and A. The batch parameters %3, %4, %5, %6, %7, and %8 are blank and are ignored. The programs set ii, the

interest rate, equal to the historical value i for the period 1947 to 1984; runs an LS regression in which INV1 (investment in sector 1) depends on the economy-wide interest rate and output in sector 1, over the period 1949 to 1984 (the first year in the sample changes from 1947 to 1949 to accommodate the two lagged values of the interest rate); sets the interest rate equal to a constant 8 percent; forecasts what investment would have been with the constant interest rate and names the forecast INVFA1; computes the ratio of the forecast variable to actual investment as IRFA1 = INVA1/INV1; and computes the ratio of forecast investment to output as IQFA1 = INVFA1/Q1.

To use instrumental variables, one could call

```
RUN REGRESS TSLS 1 B @
MS  MS(-1)  X  X(-1)  T
```

The least-squares regression is now two-stage; the fourth line of the program executes

```
TSLS  INV1  C  ii  ii(-1)  ii(-2)
Q1  Q1(-1)  @  MS  MS(-1)  X
X(-1)  T
```

The remainder of the program operates in the same fashion, except that the forecasts are named INVFB1, IRFB1, and IQFB1.

With 20 manufacturing sectors, 40 regressions require as many RUN commands. Having used a mainframe statistical package in which such batch programs were not easily done, I can testify that the batch facility not only speeds things up but increases accuracy—it is far too easy to make a typing mistake that goes undetected when you have to retype the equations of the Regress program 40 times. Moreover, microTSP allows you to repeat the last command line by pressing Control-A; repeating Control-A recalls up to the last 10 lines. Thus, in the sequence above, one would type out RUN REGRESS LS 1 A; wait for the TSP prompt, then Control-A, change the 1 to a 2, press the carriage return, etc. It is relatively difficult to make a mistake in such a routine, and easy to catch when you do.

There are three limitations on the batch programs that severely restrict their power. Plots and graphs cannot be batched; since the printing of graphs is very slow in microTSP, this is a real liability. Moreover, batch programs cannot be nested—you cannot put the 40 RUN REGRESS commands above into a batch program to call the 40 commands in turn. Nor can you use conditional statements (IF. . . THEN) or conventional loops (FOR . . . NEXT) in the batch programs. Removing these restrictions in a future release of microTSP would change the batch facility from useful to superb.

INTERFACE WITH SPREADSHEETS

Version 4.1 of microTSP provides for easy access to the Lotus 1-2-3 and Symphony spreadsheets. The recommended normal storage routine in microTSP is to save each series as a separate file with the command STORE. For communications purposes, you use the command WRITE to write a number of series to a file, which, as one option, can be defined as a Lotus .PRN file. Close TSP, load 1-2-3, and use the 1-2-3 command /FI to read the file into a spreadsheet. To move back, save the file in 1-2-3 with a /PF command; microTSP reads the file with a simple READ command. The microTSP user thus has quick access to Symphony's communications facility for accessing data banks electronically, and to the macro capabilities of 1-2-3 and Symphony, which are much more powerful than the batch facility in microTSP.

Incidentally, I was initially frightened away from using multiseries files as a standard means of storage on microTSP by the ominous, unexplained warning in the manual: "We do not recommend maintaining data banks with this type of file." Having mastered the use of such files with 1-2-3, I now employ them for virtually all storage, with no problems whatever. For example, the 20 output variables (Q1, Q2, . . Q20) in the example above can all be stored in one file called Qset; I use a simple batch program to create such files. Fewer larger files make it easier to weed out obsolete files, increase disk-access speed, and may eliminate the need to create a subdirectory. In the next version of the manual, the warning just cited should be justified or withdrawn.

DOCUMENTATION AND USER SUPPORT

The microTSP manual is extremely well written and takes the user step by step through the various features of the program. A separate sample data disk provides data for hands-on examples of regression and forecasting with several different dependent variables: telephone demand by county in California, U.S. auto sales, sales revenue for Holiday Inns, the U.S. Treasury bill rate, and the portfolio of Wells Fargo Bank.

Especially valuable for those beginning regression analysis is the manner in which the different estimating techniques are carefully related to the

(continued)

Listing 1: *The microTSP program Regress.*

```
SMPL 47 84
GENR ii = i
SMPL 49 84
%0  INV%1  C  ii  ii(-1)  ii(-2)  Q%1  Q%1(-1) %3 %4 %5 %6 %7 %8
SMPL 47 84
GENR ii = .08
SMPL 49 84
FORCST INVF%2%1
GNER IRF%2%1 = INVF%2%1/INV%1
GENR IQF%2%1 = INVF%2%1/Q%1
STORE INVF%2%1 IQF%2%1
```

TIME SERIES IN STATISTICAL ANALYSIS

Time-series analysis involves data in which the different records refer to different periods of time, generally separated by a constant interval, such as a week or a year. It is distinguished from cross-section analysis, in which the records are for different observations at a single point in time.

An alternative to time-series analysis as practiced by social scientists is the Fourier analysis used in the physical sciences. The Fourier series, as a statistical tool, seems most appropriate when the researcher is looking for a steadily repeating pattern (e.g., of light waves or electric impulses), as is often the case in the physical sciences.

In the social sciences, where observations are often drawn from nonrepeatable historical data (e.g., we can never "rerun" the economy or politics of the 1950s), researchers have tended to analyze data with time-series routines, in which a dependent variable is regressed against independent variables, with the different observations referring to different periods of time. Time itself often appears as one of the independent variables. Periodic relations are generally assumed to refer to specific calendar periods—such as a month or a quarter (three months)—and are estimated with the coefficients of particular variables in a multiple regression.

Consider a regression to explain quarterly steel production in the U.S. S, as a function of time t, the rate of capacity utilization in manufacturing CU, and three quarterly variables Q1, Q2, Q3, where Q1 is 1 in the first quarter and 0 otherwise, Q2 is 1 in the second quarter, and so on

$$\log(S_t) = b_0 + b_1 t + b_2 t^2 + b_3 CU_t + b_4 CU_{t-1} + b_5 Q1 + b_6 Q2 + b_7 Q3 + \mu_t$$

The error term in the regression is represented by μ_t. This kind of regression separates the growth (or decline) of steel production into three parts: a trend component (estimated with the b_1 and b_2 terms), a cyclical component (the b_3 and b_4 terms), and a seasonal variation component (the b_5, b_6, and b_7 terms). By writing the log of production as the dependent variable, we know that the trend rate of growth—the time derivative of log(S)—is $b_1 + 2b_2t$. If b_2 is 0, then b_1 shows the annual trend rate of growth of production when the cyclical and seasonal components are eliminated; if $b_2 > 0$ (or < 0), then trend rate of growth is accelerating (or decelerating) during the period.

The cyclical terms in the equation above show the response of production to changes in overall economic conditions, measured here with the rate of capacity utilization in manufacturing during the last two quarters (the subscript $t-1$ indicates a one-quarter lag). Finally, seasonal variation is estimated with the quarterly variables: If production is usually significantly above the trend in the third quarter, we expect b_7 to be positive. If the fourth quarter is generally the best, then the sum of b_5, b_6, and b_7 should be negative.

In ordinary least-squares (OLS) regression, the coefficients are estimated so as to minimize the sum of the squares of the error terms, on the assumption that the error terms are normally distributed with a mean of zero, have a constant variance for all t, and exhibit zero covariance among different error terms. The OLS procedures are not warranted if these assumptions about the error term are violated, which can arise for many reasons. A very common problem in time-series regressions is serial correlation, which arises when the various error terms are correlated with one another. For example, if we are estimating the equation

$$Y_t = b_0 + b_1 X_t + \mu_t$$

and if each error term is a linear function of the previous error term, we speak of a first-order autoregressive error process

$$\mu_t = p\mu_{t-1} + e_t$$

where p is a constant, and e satisfies the assumptions about the error term outlined above. An alternative to the simple OLS estimators in this case is the Cochrane-Orcutt procedure (contained in microTSP), which combines previous equations as follows

$$(Y_t - pY_{t-1}) = b_0(1 - p) + b_1(X_t - pX_{t-1}) + e_t$$

The iteration works as follows: The Y_t equation is estimated, and the residuals are regressed in the μ_t equation to get an estimate of p; that value of p is substituted in the previous equation $(Y_t - pY_{t-1})$, and the resulting residuals are again regressed in the μ_t equation to get a new estimate of p, which is again used in the $(Y_t - pY_{t-1})$ equation. The procedure continues until p converges to a constant. This procedure is perhaps better known among economists than other social scientists; most statistical packages on the market do not include it.

We can generalize the μ_t equation to speak of an autoregressive process of order n

$$\mu_t = p_1\mu_{t-1} + p_2\mu_{t-2} + p_3\mu_{t-3} + \ldots p_n\mu_{t-n} + e_t$$

An alternative to this is the moving-average error process of order n

$$\mu_t = e_t + q_1e_{t-1} + q_2e_{t-2} + q_3e_{t-3} + \ldots q_ne_{t-n}$$

The p_h and q_h ($h = 1, 2, \ldots n$) are constants analogous to the constant p in the $(Y_t - pY_{t-1})$ equation. The autoregressive (AR) and moving-average (MA) processes are combined in ARMA or ARIMA models. Such models often seek to forecast a variable, for example, Y, solely in terms of its previous values. Generally, the first step in the forecast is to take differences on the variable to be explained to remove any trend. If the trend of Y is a linear function of time, one difference will suffice, and the regressions will seek to explain $DY = Y_t - Y_{t-1}$; if Y is a linear function of time and time squared, then two differences will be required, and so on. The models then seek to explain a time series of the differenced variable with a regression using a combination of autoregressive and moving-average error terms. Forecasting involves adding the estimated differences in future periods to the previous period's value, beginning with the most recent period for which the true value is known.

different economic and business contexts; the manual shows clearly the appropriate applications of the various econometric routines and the meaning of the statistical output generated by each. At many points readers are directed to two books, a general econometrics text by Robert S. Pindyck and Daniel Rubinfeld (*Econometric Models and Economic Forecasts*, New York: McGraw-Hill, 1980) and the classic ARIMA study by George E. Box and Gwilym Jenkins (*Time Series Analysis: Forecasting and Control*, Oakland, CA: Holden-Day, 1976).

My major quibble is that a section should be added to the manual for those with no PC-DOS experience. The use of the DOS DiskCopy, Make Directory, Change Directory, and Directory commands should be explained as part of data disk management and backing up. I also think that the manual should have several additional pages illustrating batch programs.

I had a question about subdirectories and telephoned Quantitative Micro Software. The author of the program called me back within two hours—you can't beat that for user support.

CONCLUSION

Version 4.1 of microTSP contains a number of important advances over 4.0: the creation of model and batch files is greatly improved; the facility SOLVE will solve a system of many equations by the iterative Gauss-Seidel method; the PLOT command now allows many options; the STORE command for saving data files is better (it was too easy to lose data with the old STORE because only the current sample remained on the disk); interaction with Lotus 1-2-3 is improved through the use of .PRN files.

In my view, the next version of microTSP should contain a significant update of the batch facility, to allow for the use of If. . .Then and For. . . Next conditions and loops in batch programs, the nesting of batch routines, and the ability to batch graphics. The use of 256K bytes of RAM, while reasonable in 1984, is inadequate in 1986: A version of TSP for 1 megabyte of RAM would speed up computations and allow the estimation of simultaneous-equations regression models.

The program microTSP is largely successful in its effort to bring mainframe power and convenience to the microcomputer. It is easy to use and easy to learn. Researchers doing simultaneous-equations models and advanced techniques like ridge regressions will remain on the mainframe, but those running ordinary and two-stage least squares now have a convenient alternative that allows them to stop paying mainframe charges and to take their disks home at night. ■

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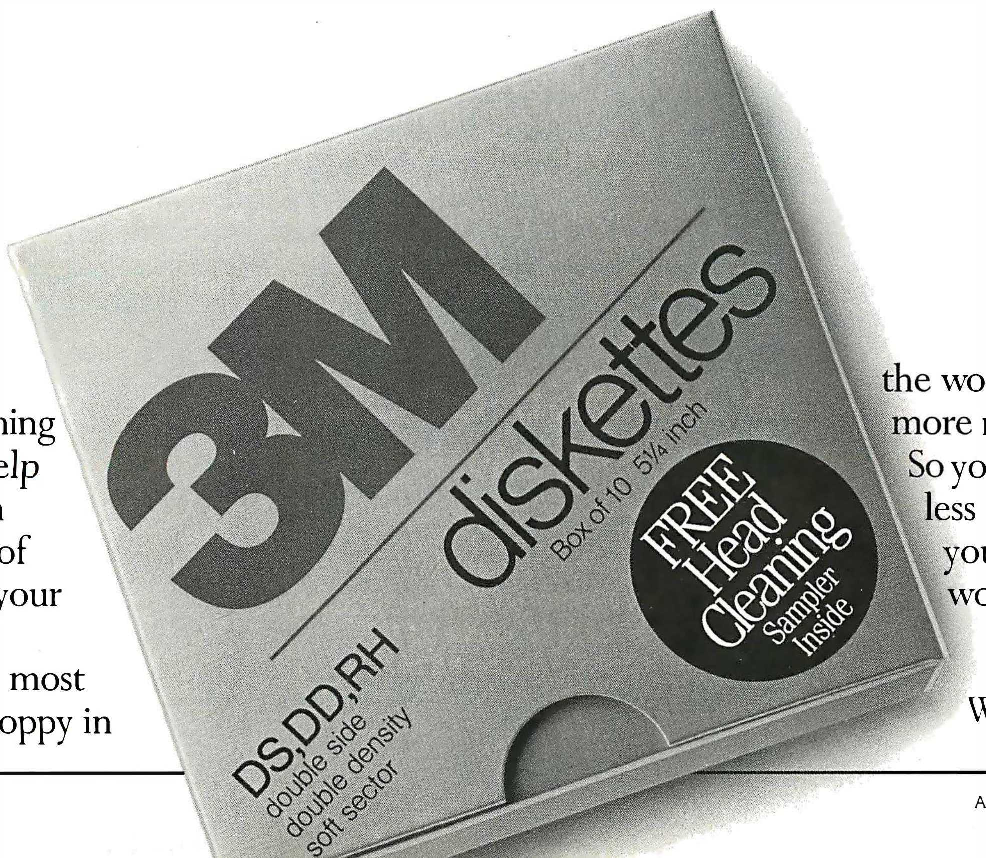
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S·O·F·T·W·A·R·E R·E·V·I·E·W

PCTeX *and* MicroTeX

Professional typesetting on MS-DOS machines

BY HAL R. VARIAN

TeX (pronounced "tech") is a powerful typesetting package developed by Donald Knuth of Stanford University. It gives you unprecedented control over the appearance of typeset output and is especially valuable for setting "penalty" text such as mathematics, tables, foreign languages, technical material, and so on. You can get the complex output in figure 1 by typing:

```
$$F(b) - F(a) = \int _a^b f(x) dx $$
$$f'(x) = \lim _{\delta \rightarrow 0}
{f(x+\delta ) - f(x) \over \delta }$$
```

The TeX system was written in Pascal to be portable, and it has been installed on a variety of mainframes, primarily at universities and research institutes. (The source code is available from Knuth at a nominal cost.) Despite its portability, however, TeX typically takes some time and effort to install on a new machine due to its size and complexity. Only recently has it become available on a low-cost microcomputer system, and two very nice TeX systems are now available for IBM Personal Computers MS-DOS machines.

How TeX Works

TeX is a formatter, not a word processor. You can compose your text using any editor that produces a straight ASCII file and insert commands in the text file to control the appearance of the final document. Then you send the ASCII file to the TeX program, which reads and processes it. TeX writes a DVI (device-independent) output file that consists of tightly coded commands to accomplish, for example, the following: move to such-and-such location, set character *n* from font *m*.

You run the DVI file through a DVI driver to actually print the typeset file on an output device. These DVI drivers are not part of the TeX package itself but are developed independently for each different output device. The final output looks the same—except for resolution—no matter what device you use. You can print draft output at 120 dots per inch on a dot-matrix printer, then run a preliminary distribution copy on a 300-dpi laser printer, and then typeset the final version on a 1200-dpi phototypesetter.

The TeX system has a powerful macro-processing facility and is virtually a language unto itself. Large libraries of macros have been created to handle a variety of typesetting chores. Such macro packages can hide the technical details of the particular design from the user while giving the designer great flexibility in creating a unified document style.

For example, you could create a macro called \title that skips 20 points, centers the text that follows it, prints the text in 14-point boldface roman, and skips another 20 points. If you change your mind about the style you want in the document, you can simply change the definition of \title so that, for instance, it moves to the top of a new page, prints 16-point small-caps text, and skips 30 points. You don't need to change anything else in the document.

TeX can accept such macro packages as input in two forms: as straight ASCII text files or in a highly compressed form called an FMT (formatted) file. The second form is desirable for packages that you use often because it is much faster. There are many standard packages of TeX macros, such as AMSTeX, LaTeX, and so on, that aid in document design. These are usually provided in ASCII form and then converted to FMT form at each installation, since the FMT form has some machine-dependent features.

PCTeX and MicroTeX on the IBM PC

Some features are common to both PCTeX and MicroTeX. First, they each require a large system. At a minimum, you need 512K bytes of memory and a hard disk. If you want to load all the fonts provided, the systems can each use up to 6 megabytes

(continued)

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AT A GLANCE

Name	PCT$_E$X	MicroT$_E$X
Type	An implementation of the T$_E$X typesetting package	An implementation of the T$_E$X typesetting package
Company	Personal T$_E$X Inc. 20 Sunnyvale Ave., Suite H Mill Valley, CA 94941 (415) 388-8853	Addison-Wesley Publishing One Jacob Way Reading, MA 01867 (617) 944-3700
Format	For the IBM PC and other MS-DOS computers; includes print driver and fonts; requires at least 512K bytes of memory and a hard disk	For the IBM PC and other MS-DOS computers; includes print driver and fonts; requires at least 512K bytes of memory and a hard disk
Documentation	100-page system description manual, 150-page LaT$_E$X manual, *The T$_E$Xbook*, T$_E$X tutorial	60-page book primarily describing the print driver; *The T$_E$Xbook*
Price	$379	$495

of disk space. (If you don't want all the fonts, you can get by with substantially less disk space—a megabyte or two—for the programs and a few font packages.)

Second, both implementations use exactly the same user interface. This is not surprising. Knuth has copyrighted the T$_E$X name, and a system can be called T$_E$X only if it adheres to certain rigid standards. Thus, T$_E$X looks the same regardless of whether you run it on a large mainframe, an IBM PC, or any other machine.

Since portability is built in, each of these packages should run on any MS-DOS system without modification. Both PCT$_E$X and MicroT$_E$X provide an accurate and complete implementation of T$_E$X and produce standard DVI files. These are not miniatures of T$_E$X; you get the real thing: a full-scale professional typesetting system.

The performance of PCT$_E$X and MicroT$_E$X also turns out to be similar. The major features distinguishing the two systems are the documentation, a few capabilities, and the print drivers.

PCT$_E$X FROM PERSONAL T$_E$X

PCT$_E$X comes on 13 disks and has a 100-page manual describing the system. The distribution material includes several disks containing LaT$_E$X and the 150-page LaT$_E$X documentation. LaT$_E$X and the T$_E$X fonts are in the public domain and can be freely distributed. The proprietary part of PCT$_E$X consists of only two programs: T$_E$X itself and a device driver for the Epson FX-80 printer called PCDOT. The rest of the disks consist primarily of font definitions for PCDOT. Despite being stored in compressed form, these fonts take up a lot of room.

Lance Carnes, an experienced T$_E$Xnician, ported PCT$_E$X to the MS-DOS environment using Knuth's original Pascal source code. The major problems he encountered were modifying the standard system calls, handling memory management for T$_E$X's very large arrays, and manipulating the 32-bit integers that T$_E$X uses in its internal computations.

$$F(b) - F(a) = \int_a^b f(x)dx$$

$$f'(x) = \lim_{\delta \to 0} \frac{f(x+\delta) - f(x)}{\delta}$$

Figure 1: *An example of the type of technical text that these microcomputer implementations of T$_E$X can handle.*

The documentation for PCT$_E$X is excellent. The official book for the system is *The T$_E$Xbook* (Addison-Wesley, 1984), and it is an imposing document. However, beginners often find it quite difficult reading despite the fact that it is written in an entertaining and instructive manner. PCT$_E$X is therefore packaged with a tutorial by Michael Spivak, a well-known and experienced T$_E$X wizard and author of a number of highly respected mathematics books. I know of no better introduction to T$_E$X. It will get you up to speed quickly and let you save *The T$_E$Xbook* for detailed reading at your convenience.

PCT$_E$X has the ability to create and read FMT files. Thus, if you use a lot of macros (designed either by you or by someone else), you can create binary representations of them that you dump to disk and then load at high speed each time you run T$_E$X. PCT$_E$X provides two such macro packages with the system: the LaT$_E$X system and a small set of macros designed by Spivak called VANILLA.STY. Spivak's package has a few of the features of AMST$_E$X, a macro package that he designed and which has been adopted by the American Mathematical Society.

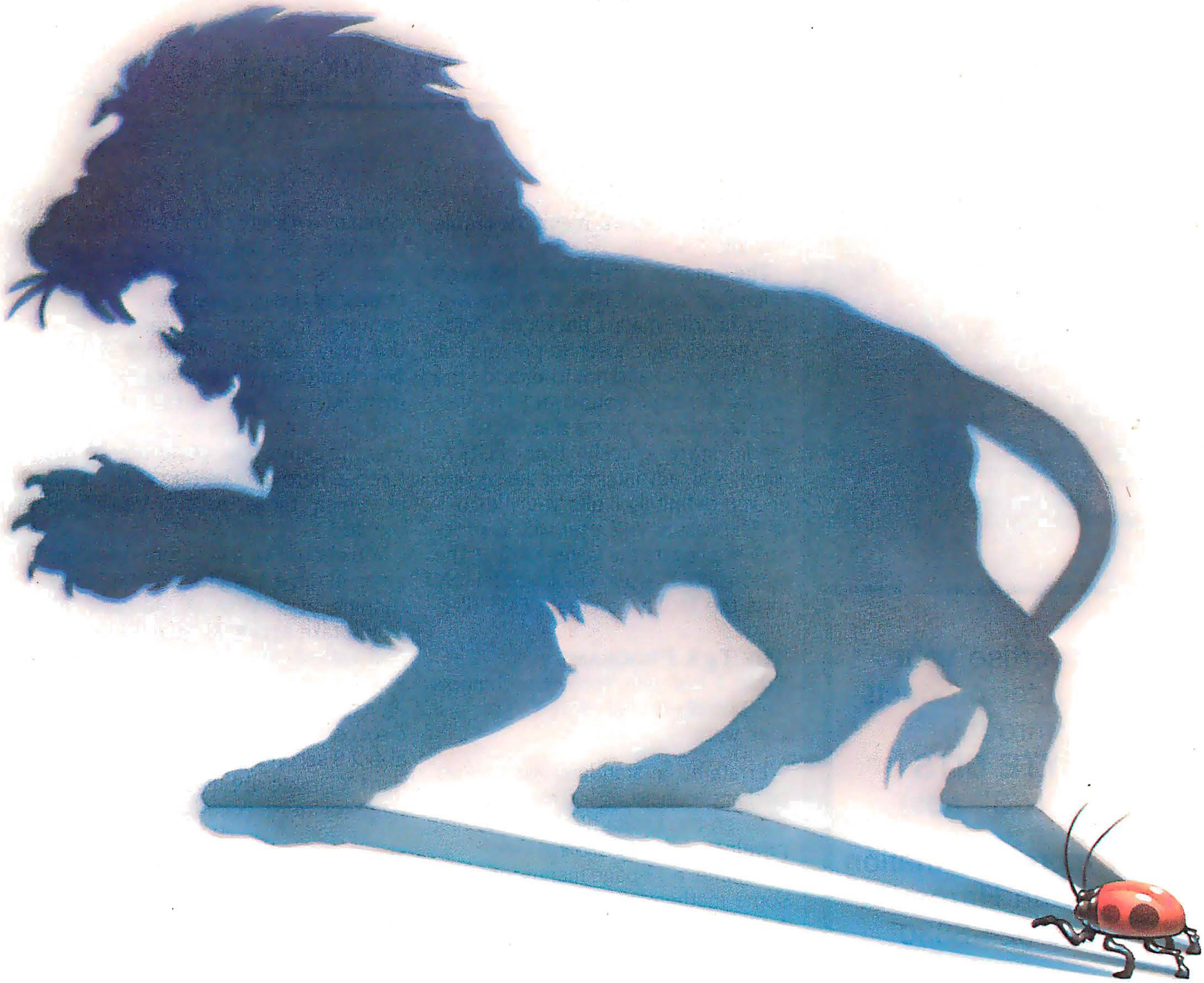
MICROT$_E$X FROM ADDISON-WESLEY

MicroT$_E$X comes on eight disks. T$_E$X and the print driver take up three of them. The rest contain the font specifications used by the print driver.

The documentation consists of *The T$_E$Xbook* and a 60-page manual primarily concerned with the print driver. The manual is quite clear, but it is definitely not a T$_E$X tutorial. *The T$_E$Xbook* is the definitive reference manual but, as noted earlier, is often difficult for beginners.

The program itself was ported to the IBM PC by David Fuchs, a longtime member of the T$_E$X project at Stanford. He translated the entire T$_E$X system into C rather than use the original Pascal. As far as I can tell, this translation is totally transparent, and this implementation of T$_E$X looks like

(continued)



every other one—a highly desirable feature.

The major difference between MicroTeX and PCTeX is in the way they handle macro packages. Addison-Wesley has chosen to preload the PLAIN format and not to provide the ability to create your own FMT files. The first choice means that MicroTeX loads more quickly than PCTeX, which is an advantage, but the second choice definitely limits your flexibility. The casual TeX user would probably appreciate the faster loading; the serious TeX user would definitely miss the facility to create FMT files.

THE TeX PROGRAMS

Table 1 contains some benchmarks for MicroTeX and PCTeX. The test files were:

- Errata-b: a standard benchmark package consisting of eight passes through the Errata file from the first printing of *The TeXbook*
- Volume: a 13-page manuscript with some mathematics
- Matrix: a 4-page manuscript with several matrices
- Webman: the manual for WEB, a program-documentation system provided by Knuth

The best benchmark for these two systems is the multiple-pass run through the Errata file, since that file contains a variety of text and is a standard used to compare other TeX systems. As you can see, the performance of the two systems is virtually identical for this document. In fact, the only serious difference in the benchmarks is on the Matrix document. Matrices are hard to set up and require a lot of calls to various alignment routines. The performance difference here may be due to the ways in which these calls were implemented.

You should be aware that the times given in table 1 are for an IBM PC AT running at 9 MHz. A standard AT would take about 30 percent longer, and a standard PC XT about 200 percent longer. As a rough guide, you can figure that the 9-MHz AT takes about 6 seconds per page, a 6-MHz AT takes about 8 seconds per page, and a standard XT takes about 18 seconds per page for most documents.

THE PRINT DRIVERS

Both Personal TeX and Addison-Wesley provide a device driver for printers compatible with the Epson FX-80. They are similar in nature: Both use the standard TeX fonts, offer similar performance, and have nearly the same names. However, there are some differences. The MicroTeX driver has several extra bells and

(continued)

Table 1: TeX *benchmark. The columns compare the four different test files run by each of the packages.* (*Times are given in minutes:seconds.*)

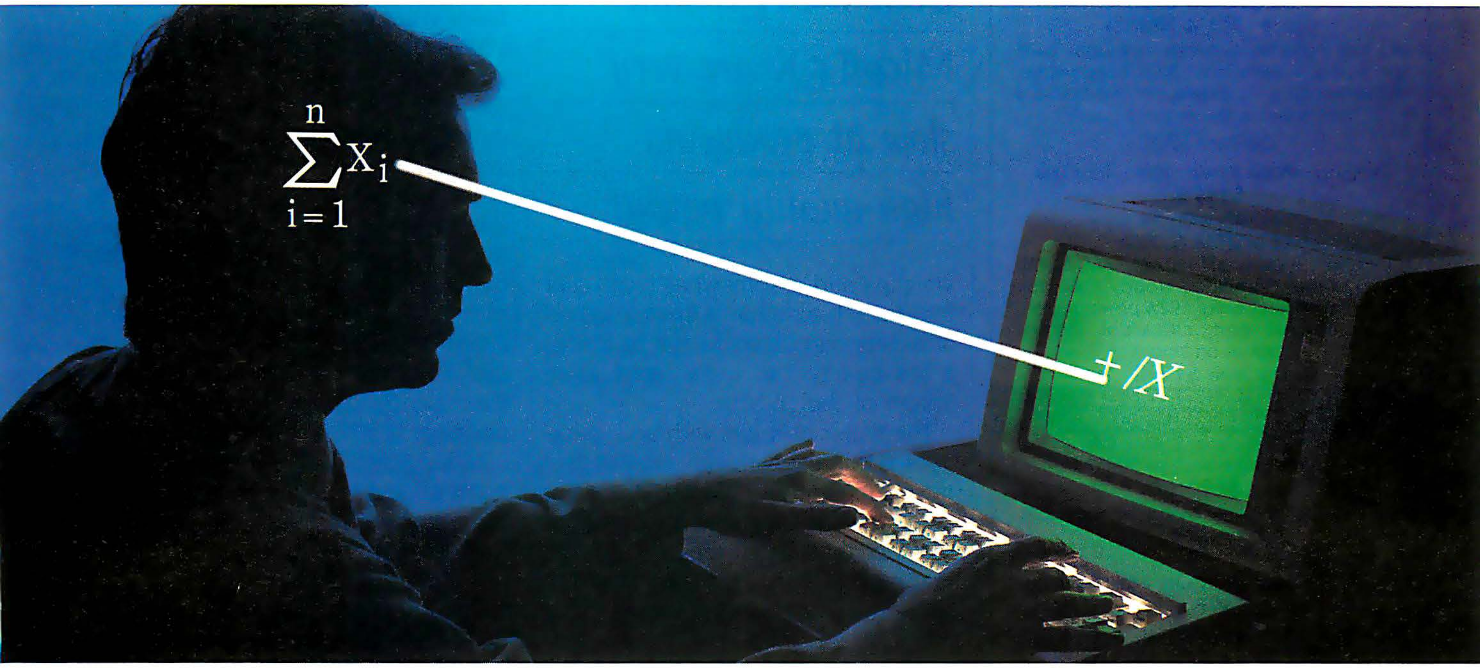
	Errata-b	Volume	Matrix	Webman
MicroTeX	11:39	1:15	1:05	2:35
PCTeX	12:00	1:28	0:37	2:31

Table 2: *Print-driver benchmark. The columns represent levels of print quality;* MicroTeX *offers five,* PCTeX *offers two.* (*Times are given in minutes:seconds.*)

	1	2	3	4	5
MicroTeX	7:13	2:01	1:59	0:52	0:50
PCTeX	7:43	2:08	—	—	—

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Both PCT$_E$X and MicroT$_E$X are very slow at producing high-quality output.

whistles and a somewhat nicer user interface. It also has a special quick-and-dirty output mode that produces a low-quality, but quite rapid, print image of the DVI file.

The major problem with both packages is that they are very slow at producing high-quality output. This is not a fault of the programs but is due to the fact that each does a full-page graphics dump, which is an unavoidably slow process on most dot-matrix printers.

Most serious users of T$_E$X would probably use these drivers for draft output only, but the highest-quality mode looks very good. One user described it as "a laser printer on a bad day," and the description is an accurate one. After all, the Epson at 240 dots per inch is not so different from a Canon-engine laser printer at 300 dots per inch. If you print in a 12-point font and then reduce that to 10-point on a photocopying machine, you can get very nice looking output indeed.

But you pay a price for this quality: It can take more than 7 minutes to print a page in the high-quality mode (see table 2). MicroT$_E$X has five quality levels, while PCT$_E$X has two and is slightly slower at producing similar-quality output.

Other Print Drivers

Other dot-matrix device drivers for DVI files are available. Personal T$_E$X sells a print driver for the Epson LQ-1500 and the Toshiba dot-matrix machines. (Performance on the newer dot-matrix printers should be better due to improved hardware.) Personal T$_E$X also sells laser-printer DVI drivers for the Corona Laser printer, the QMS Lasergrafix, and the Apple LaserWriter. Addison-Wesley plans to support more output devices.

I have had experience only with the LaserWriter driver, DVILASER/PS, but I have been very impressed with its performance. It was written by Textset Inc. (416 Fourth St., POB 7993, Ann Arbor, MI 48107) and is sold as an option for both PCT$_E$X and MicroT$_E$X. DVILASER/PS processes pages at a rate of about 5 seconds per page on the AT running at 9 MHz and prints them out at about 4 to 5 pages a minute. DVILASER/PS translates Knuth's device-independent format into PostScript commands, which it then sends to the LaserWriter for printing.

DVILASER/PS allows you convenient access to many PostScript features such as automatic scaling, rotation, graphics, and the LaserWriter's resident fonts, as well as the standard Computer Modern fonts designed by Knuth. The output looks great: PostScript and T$_E$X together are a terrific combination.

Textset also provides print drivers for various laser printers and phototypesetters, as well as other products relating to T$_E$X. One particularly interesting new product is a preview-screen program for the IBM PC family and the Hercules graphics board; it allows you to see your manuscript on the screen before you print it.

Conclusion

Both of these packages are full and complete T$_E$X systems. They are each excellent products, and either should serve you well. The primary advantages of PCT$_E$X are that it produces FMT files for the rapid loading of macro packages; it comes with LaT$_E$X, a well-known macro package; and it contains an excellent T$_E$X tutorial by Michael Spivak. The primary advantages of MicroT$_E$X are that it provides a quick-and-dirty draft-print mode, and it is a little faster at producing quality output. ■

[Editor's note: For more information on the T$_E$X system and digital typography, see the interview with Donald Knuth entitled "Computer Science Considerations" in the February BYTE, page 169.]

ADVANTAGE!

I read TJ Byers's review "Advantage! for the AT" (January, page 327) because we were considering purchasing these boards for the Computer Resource Lab at MIT. The key feature I found in installing such cards from scratch is that the AT is only able to recognize expanded memory above 1 megabyte starting on a half-megabyte boundary. This is not made clear in the AST documentation. Thus, if you install an AST card with 384K bytes, with 512K bytes on the motherboard, and a 512-byte expansion card (such as in the Enhanced AT), you are in effect not able to use the AST card with split memory addressing. The 256K bytes left on the AST card after 128K bytes have been added to the 512K bytes on the motherboard are virtually unusable, since it would start at 1.1 megabytes. Prior knowledge of key features is always an advantage!

SIMON LEWIS
Cambridge, MA

ENABLE

The Software Group believes the review of Enable by Steve King with a text box by Rich Malloy (January, page 331) was largely misleading, and we'd like to address some of its inaccuracies.

- "All the documentation [is written] as a tutorial." This is not true, although portions include tutorial sequences as reinforcement of the text.
- "The MCM [Master Control Module] doesn't display files that were not created by Enable." Enable not only reads but converts files from and to a variety of formats.
- "The menus do not help you learn the keyboard commands." Enable's design accommodates users who want either a menu-driven application or a command-driven application.
- "The backspace key sometimes reverts to its default behavior [even after the profile is adjusted]." Did you specify NO PROFILE at the sign-on screen? If so, Enable reverts to its internal (unchangeable) system profile.
- "The Enable 1.0 spreadsheet. . .cannot read files. . .in 1-2-3, VisiCalc, and DIF formats." Version 1.0 can read all these formats, without any rekeying.
- "I chose DBMS to integrate the. . .database with my text." The DBMS option on the top-line menu is not intended as a means of integrating your data; it provides a way to look something up in your database while writing a word-processing document.
- "[The telecommunications module] stores your desired parameters on the utility disk, but the operation disk looks for these parameters on your data disk." We recommend copying the telecommunications setup file to the data disk.
- Enable "locked up irretrievably" when directed to print on a Star Micronics Gemini after you configured Enable for an Epson MX-80. We tell Star Micronics users to choose the Epson RX-80 configuration.
- "Copying a block of text seems to cause some paragraph indentation in the block to be lost." Enable's block-copy feature always copies text to the flush-left position to save you keystrokes when positioning your cursor.

MIKE FISSELL
The Software Group
Ballston Lake, NY

I have been using Enable versions 1.0, 1.01, and 1.1 in a working environment for over a year. Steve King's review of Enable was so at odds with my experiences that I feel I must respond.

Enable's reformatting, as reported by both Steve King and Rich Malloy, has a few rough edges, particularly in dropping double spaces following periods and occasionally losing indentation on block moves. However, dealing with lines longer than 78 characters is not one of Enable's problems: I cannot remember using a version of Enable that did not allow me to use lines as long as 160 characters. I have learned to live with the program's quirks, which rarely cause me serious problems.

The database module is almost unusable without a hard disk, but that is true of every other micro DBMS I have used. I am surprised that King felt Enable's DBMS was the strongest part of the package. I found Enable's DBMS much less satisfactory than either the word-processing or spreadsheet functions. I can agree with King and Malloy about the relative weakness of Enable's telecommunications abilities. They are adequate for TTY emulation on dial-up lines, but the VT100 emulation is too slow, at least on a 9600-bps line.

In a working environment, if I had limited resources and could afford only one piece of software for an IBM PC, I would choose Enable.

SELDEN S. DEEMER
Atlanta, GA

You state, "I have learned to live with the program's quirks." I believe that personal computer software consumers shouldn't have to learn to live with the quirks of any software costing more than $5 or $6 (that is, public-domain programs where you only pay disk costs). If you spend your hard-earned money on software, you have a right to bug-free, tested programs. Furthermore, software should contain a complete inplementation of all the features the manufacturer advertises and implies you're getting. That's the primary point of my review—the user interface is secondary and a matter of preference. As a reviewer, I also believe that I should point out what I liked and disliked to assist readers with their decisions about software purchases.

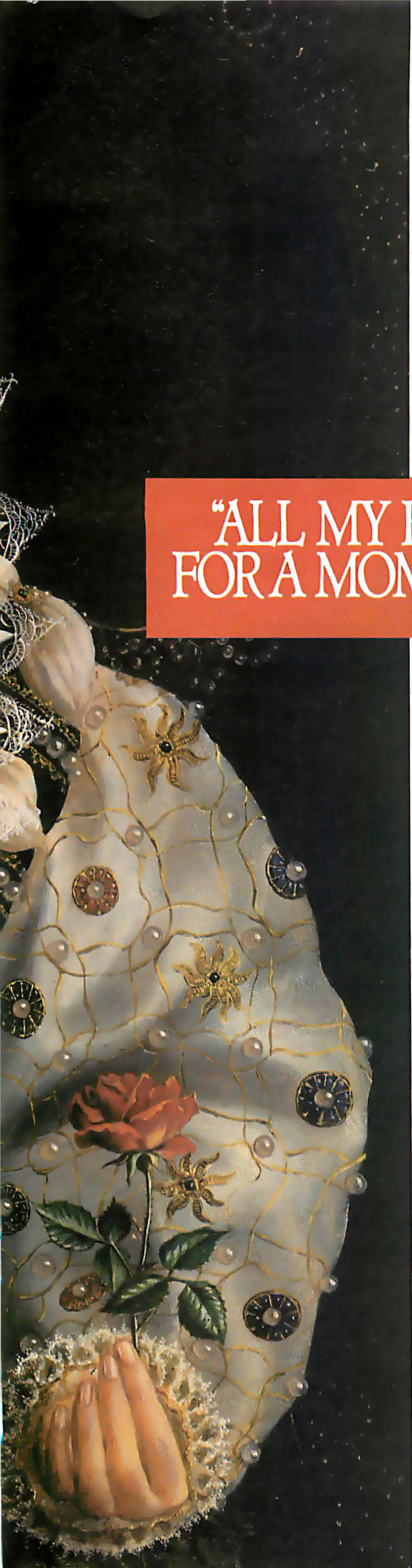
I use PC-Write for editing, WordPerfect for word processing, Paradox for data management, Reflex instead of a spreadsheet, and PC/InterComm for communications. None of those programs required me to learn to live with their quirks. They all perform as expected, can import/export formatted ASCII files, and are probably all as fast as Enable.

Because I had read such positive reviews of Enable in other magazines, I really looked forward to working with it. I was both shocked and disappointed at what I actually found. Since Mr. Malloy reached similar conclusions about an even later version, I believe my review accurately reports what I found.

—STEVE KING ■

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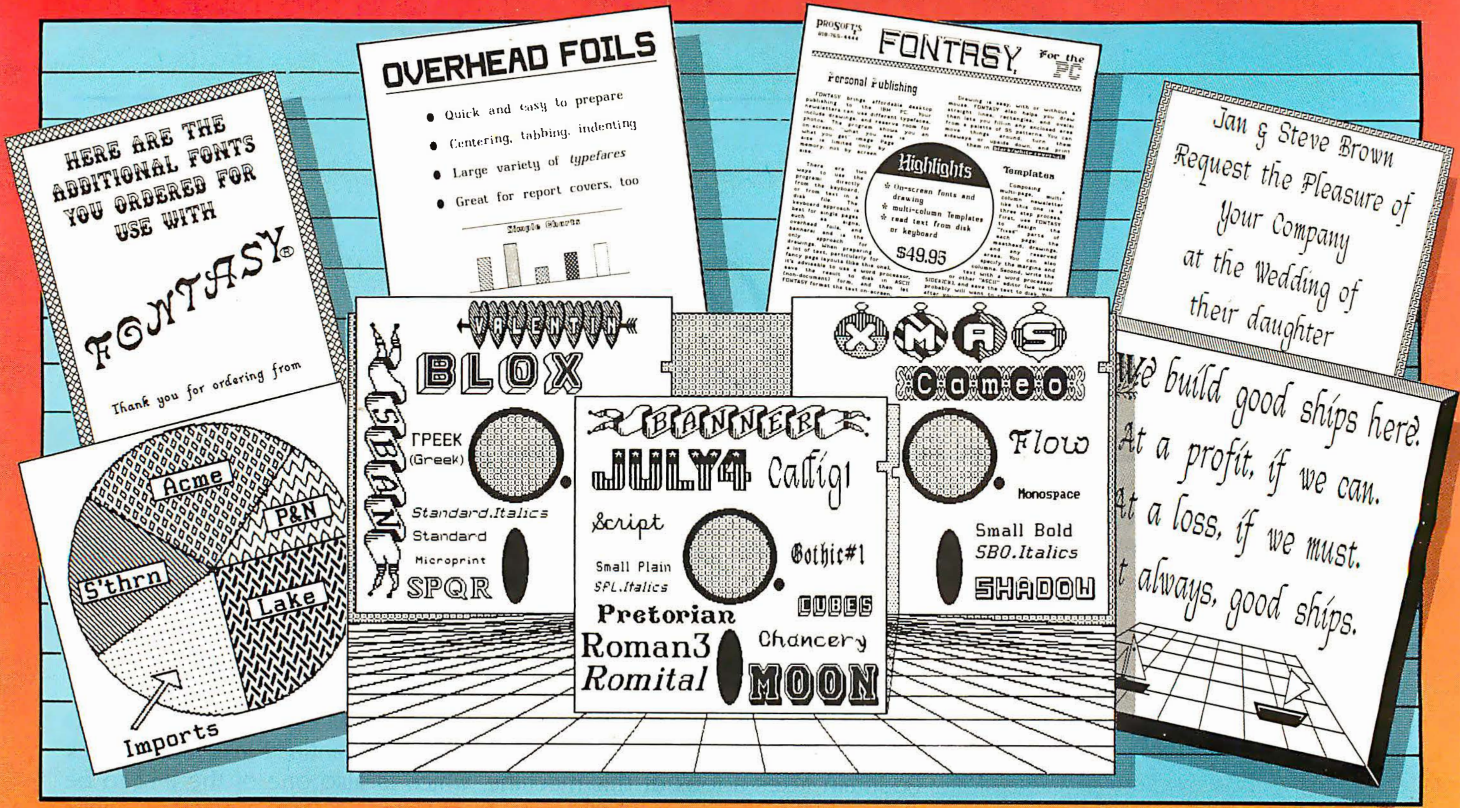
Kernel

This month's Computing at Chaos Manor begins with a report on COMDEX. Jerry came away convinced that color will soon dominate the micro industry. Following this are sections on the Amiga versus the Atari 520ST, the information revolution, a new Modula-2 compiler, and another new product from Borland International. And it's also award time at Chaos Manor, both the good and the bad. Many products appeared that Jerry has high praise for, but he also had several nominees for the Folly of the Year.

Apricot Ltd. recently unveiled its answer to the IBM PC AT—the XEN, which offers more performance than the PC AT for substantially less money. Dick Pountain takes a look at this machine, which is also one of the first to be shipped with Microsoft Windows as its standard operating environment.

In the words of Ihara Saikaku, "There is always something to upset the most careful of human calculations." Bruce Webster certainly subscribes to that. His column this month was supposed to be the second round of the 68000 wars. However, because of planned announcements of new machines from Atari and Apple, he postponed it until next month. This month, he looks at new software for the Macintosh, the Amiga, and the Atari 520ST.

This month, Ezra Shapiro talks about two programs he has begun to use daily. Mirror is a telecommunications program that is similar to Microstuf's Crosstalk XVI but costs half as much. Framework II is an improved version of the original Framework.



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Jerry's Best of 1985 Awards

BY JERRY POURNELLE

December is a busy month at Chaos Manor. Everything happens at once. I've just returned from COMDEX. Christmas is coming. I've caught my customary attack of the flu. It's time for my 1985 Best of the Year awards; and since this will go in the April issue, it's also time for the Folly of the Year. Stand by.

COMDEX was hectic. The United States Space Foundation's annual meeting was in Colorado Springs for the first part of the week, overlapping COMDEX by three days. I spent an enjoyable afternoon with faculty and cadets at the Air Force Academy on Wednesday, but of course my luncheon speech to the Space Foundation came on the same day as the Hearst/Pournelle/Dvorak COMDEX party in Las Vegas. I had things all planned out, but Colorado's weather bollixed things, so I found myself frantically changing planes. Even so, I didn't get to Las Vegas until about 9 p.m. Thursday evening.

I'd been told that the party was to be in the shopping mall of the Las Vegas Neiman-Marcus. This seemed unlikely, but there were no messages at my hotel, so off I went. When I got to the Fashion Mall, I found polite but astounded security guards, no one else, and no pointers to the real location. I was ready to strangle John Dvorak.

Still, one must cope. So at 10:20 p.m., having been escorted out of the Neiman-Marcus plaza, I set out to find the party I was supposed to cohost. An hour later I got to it. As I arrived, some people were leaving: far more showed up than anyone had expected, and they'd run out of drinks. That dire situation was soon remedied by Borland International's Philippe Kahn, who ordered champagne and pizza for all.

I'm told it was the best party of COMDEX. Certainly there were enough interesting people, including Microsoft's Bill Gates, Cap'n Crunch, editors in chief, writers and reporters, hackers, game designers, and Bixen (inhabitants of BIX). It was crowded enough that I never did find Will Hearst, nor a number of others I wanted to see, but certainly it was The Place to be. I guess we'll do it again next year. I'd like to think it will be better organized, but it probably won't.

COMDEX

COMDEX is terribly expensive and getting more so. Every year there are more exhibits —or at least more square feet of exhibits. It's a bit like display advertising in leading magazines: companies simply can't afford not to be seen lest they be forgotten, not only by customers but by dealers.

Most companies don't have anything really new to show, but they *have* to be at COMDEX. The result is booth after booth distinguished mostly by gimmicks. One outfit has a yacht. Another has dancing girls. Yet another has grown people dressed up as children playing out a mindless skit. It's hard to find the genuine technological innovations among the magicians, vaudeville performers, ventriloquists, silly robots that whistle the theme from *Star Wars*, bowls of bubble gum, jelly beans, chocolate dollars, coffee cups, buttons, fuzzy animals, stick-ons, plastic back-scratchers, and other paraphernalia of hype. Still, the search must be made. Fortunately, there were some trends to be spotted.

One warning note: show reports describe what I saw at a show and what I concluded from things I was told. I don't make full reports on stuff until it's sitting here in Chaos Manor.

WONDERFUL WORLD OF COLOR

One thing stood out clearly: the future computer world will definitely be in color. Color has always been preferable to monochrome, but until recently, you couldn't get monitors and color cards to display text with enough sharpness and clarity. Now you can, and the best new text-editor software can take advantage of color, so that you can use, say, light-blue letters on a darker-blue background with yellow highlights, instead

(continued)

Jerry Pournelle holds a doctorate in psychology and is a science-fiction writer who also earns a comfortable living writing about computers present and future.

of white on black, or black on amber, or whatever.

Before this, I hadn't seen any affordable color display crisp enough that I could stare at it day after day; but there were several such systems at COMDEX. One of the most interesting was a neat monitor from NEC. It can display the output from the normal IBM PC color board (not really good enough for text), the Extended Graphics Adapter (which is getting there), or the Professional Graphics Adapter (which does have the capability).

NEC (1401 Estes Ave., Elk Grove Village, IL 60007) also has a new PC AT-compatible computer with some of the best color graphics and color text I've ever seen. NEC wasn't alone, of course. In fact, it was hard to find a part of COMDEX that didn't have spiffy text-quality color displays; NEC just happened to be the first one to catch my eye.

One wonderful little gadget was unique, one of the most impressive items in the show. Perma Power Electronics Inc. (5615 West Howard Ave., Chicago, IL 60648), an outfit that you usually think of as making power-guard supplies, displayed a thin color-control box for less than $300. It sits between your computer and your color monitor. Simple controls on the front let you instantly change the colors on your monitor to anything you like. Reds can become blues, greens become greener, or whatever. More to the point, you can change the whole palette from, say, your favorite word processor: different background color, different lettering, different highlight colors. I was really impressed with it at the show. More about it after I've had time to work with it here.

I came away from COMDEX convinced that, within two years, color will dominate the micro industry—and that includes business people as well as hobbyists, students, game players, and home users. Color is just too nice not to take advantage of.

ATARI

The Atari booth was over in West Hall, where crowds don't usually go, which made the ferment around the Atari booth stand out from a long way off. The Atari people brought in a bunch of software developers and set them up in minibooths reminiscent of the West Coast Computer Faire. The result was a bunch of enthusiastic young people showing what they could make the Atari 520ST do. You could get a contact high by just standing there.

I saw databases, text editors, games, accounting systems, languages and compilers, a light-show program, a music-recording program, and all kinds of other stuff. Atari wanted to

(continued)

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scotch the rumor that there's no software for the 520ST, and, in my view, they succeeded with a vengeance. I think that the Atari 520ST is here to stay.

AMIGA

The Commodore folks were not at COMDEX. They'd reserved space but didn't use it; instead, they held a press conference. The official line was that Commodore is selling all the Amiga computers it can make and thus has all the dealers it needs; it would be silly to spend all that money just to tell potential dealers they can't come aboard.

Atari's comment on that was, "We sell more Atari 520STs than Commodore sells Amigas, and we sure want to sign up more dealers." The rumor in the pressroom was that Commodore's bankers were signing its checks and wouldn't advance the money to pay for COMDEX.

I wouldn't know. What I do know is that the Commodore Amiga is one hell of an exciting machine.

AMIGA VERSUS ATARI 520ST

I've had an Atari 520ST and an Amiga set up side by side for about a week. One thing is clear: either one of these machines could eat Apple's lunch. Both machines have sharp, crisp color graphics. Neither one has a text editor good enough that I'd use it to write books, but that's a software problem: both the Amiga and the 520ST can display professional-quality text in color. It shouldn't be long before someone writes editors transparent enough for creative writers. Indeed, we already have TDI Modula-2/ST up on the Atari, and it wouldn't take a heck of a long time to *write* a good text editor.

In addition, both the Atari and the Amiga have versions of EMACS, the popular programming editor written by Richard M. Stallman. I haven't worked with the current versions, but real EMACS can be customized to know what language you're programming in, making the programmer's life much easier.

By the time you read this, both machines will have Lattice C. Lattice also has a bunch of software tools, like Text Utilities and MacLibrary, a collection of C functions compatible with Macintosh QuickDraw. Software developers are enthusiastic about these: they make it easy to convert Macintosh software to the Amiga. Meanwhile, Borland is porting Turbo Pascal to the Amiga, and, as I've already mentioned, we have TDI's Modula-2 for the Atari. The Amiga's Microsoft BASIC is, as I write this, greatly superior to the Atari's present BASIC, but once again things are changing rapidly. Metacomco, a reliable outfit, is working with Atari, and its Personal BASIC ought to be up on the Atari well before you read this. Moreover, Metacomco is also working with Lattice to bring Lattice C and Toolkit to the Atari. There won't be any shortage of programming languages for either machine.

Amiga has one major advantage. Microsoft is emphatic about having no plans whatever to port anything to the Atari; but Microsoft's Excel is still the best spreadsheet on the market, and by a lot. The 520ST with Excel would be a dynamite combination and would practically guarantee Atari's penetration into the business world. Excel is written in C for the 68000-based Macintosh, and both the Atari and the Amiga are 68000 machines; it wouldn't be that hard to get Excel onto either one.

The story I get is that Atari was originally going to run with Microsoft Windows, but when Microsoft didn't have Windows running in time for the 520ST's release, Atari went with Digital Research's GEM, which irritated Microsoft no end. Whatever the story, you're likely to see Excel on the Amiga long before it gets to the Atari 520ST. It'll be a good combination, too. Meanwhile, there's already powerful business software for the Atari, including DB Master and Quickview's Zoomracks.

In my judgment, the Atari and the Amiga between them spell big trouble for Apple. I haven't seen anything you can do with a Macintosh that you

(continued)



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can't, at least in theory, do as well with either of these two machines. Hackers assure me that it's much easier to write programs for either than for the Mac—one chap told me he could get a fancy program running on *both* the Atari and the Amiga quicker than he could get it going on the Macintosh. There are powerful languages for both machines. Both companies have sensible policies to encourage software developers, and both are really working to be nice to hackers. It shouldn't be long before the floodgates open and the software pours out. There will still be Macintosh loyalists, of course, and Apple is likely to cut Macintosh prices; but the Mac's small and colorless screen, inherent speed limitations, and lack of disk controller will count against it.

Both the Atari and the Amiga will, or at least ought to, do well against the Apple II and the Macintosh. The real question is how they'll compete with each other.

I think it's too early to tell. Each machine has strengths and weaknesses. The Amiga has multitasking. Its keyboard definitely feels better, and its color graphics are, I think, aesthetically nicer. The Amiga is also easier to set up. The Atari needs a lot of room, has cables *everywhere,* and really requires simple but specialized furniture to be useful. However, its color monitor is better than the Amiga's; to get the best from the Amiga, you will want a Sony monitor or something similar. The Atari has good sound quality, but the Amiga has even better and in stereo. And so forth.

I suppose I prefer the Amiga to the Atari; but *how much* do I prefer it? The price difference between the machines is significant, especially when you consider that the Atari will soon have a $700 20-megabyte hard disk, and many of the Amiga's hardware features can be simulated in the Atari through clever software. The Amiga is, on balance, the "better" machine—but the Atari 520ST is certainly good enough for a lot more than I originally bought my first computer for.

(continued)



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My guess is that the Amiga will appeal more to serious computer users—professional artists and writers, hackers, dedicated hobbyists—while the Atari will be the machine "for the rest of us," meaning the machine that everyone can afford. I wouldn't be surprised to see a significant portion of U.S. high school students owning Atari 520STs before the end of this decade. The machine is that good, and Atari's policy is ruthlessly to cut costs and prices.

The nice part is that the Amiga will keep Atari on its technological toes; the Atari will force Commodore to keep prices down; and both will force Apple and IBM to pay attention to something besides horoscopes and hype. The rest of us can't lose.

AT LEAST ONE CPU. . .

I don't believe in multiuser micros. "One user, at least one CPU" is Pournelle's motto. If you want multiple users, get multiple machines and network them.

My philosophy seems to be catching on. IBM introduced the PC AT as a multiuser machine, but it isn't often used that way. There probably were some, but I don't remember seeing one multiuser PC AT at COMDEX. On the other hand, I saw a lot of PC AT clones set up to do multitasking for single users.

That doesn't surprise me a lot. I've been using Big Kat, the Kaypro 286i, since last spring, and I would truly hate to go back to a less powerful machine. Big Kat is fast and, barring the hard-disk problem I previously reported, has never had a glitch.

Big Kat doesn't have enough memory. That is: the machine is full up with 640K bytes, but that's not enough for everything I want to do, what with SideKick, SuperKey, the Turbo Lightning spelling checker, Symantec's Q&A editor and report generator, and Living Videotext's Ready! outline processor.

There are solutions. Wayne Holder, whose Oasis Software brought you The Word Plus, has developed a new spelling checker and thesaurus program that works with Q&A. Symantec continues to work to reduce the program's memory requirements. Ready! will currently run on an expanded-memory board, and Gordon Eubanks assures me that Symantec is working hard to get Q&A to do the same. Meanwhile, a number of companies offer expanded-memory boards for the PC AT and its clones.

There are enough outside sources of both hardware and software for the AT to reach a critical mass. Indeed, I think it has already happened. The AT and its clones have become the new "standard" small business computer, and, from here on, more and more programs will take advantage of the

(continued)

 Inquiry 210

It can't be long before CD-ROM technology changes the way we look at and use information.

power of the AT's 80286 chip.

It can't happen too soon for me. Eventually, I suppose, the 80386 will become the "new standard," but that's going to take a while. Maybe not as long as I thought: developers are reporting that the first batch of 386s are excellent. Meanwhile, the 286 has its day.

THE INFORMATION REVOLUTION

We've seen it coming for a long time, but now the CD-ROM is here. CD-ROM is the name agreed on for using compact disks as read-only storage for computer information. The CD-ROM disk drive is about the size and price of a good floppy-disk drive. Each CD-ROM disk can hold hundreds of megabytes of information: programs, data, text files, music and speech, animation and motion pictures—all can be put onto the disk and accessed.

Phillips has CD-ROM drives for sale, and there are already a number of commercially available CD-ROM disks, along with software to access the data. Activenture, Gary Kildall's new company, has Grolier's *Academic American Encyclopedia* with a really neat indexing system; in a few seconds to tens of seconds, you can search through the whole encyclopedia. It took less than a minute to find all the references to science fiction (about a dozen) and all references to science fiction with the name Pournelle in the same article (alas, none).

The Phillips people tell me there are about 40 databases on CD-ROMs. These include back issues of newspapers, stock-market histories, all kinds of financial data, technical manuals, math handbooks, you name it. Many haven't been announced yet, but Phillips is aware of them. Meanwhile, software to access these databases is either in preparation or, like Kildall's, already available.

CD-ROM disks can be manufactured for about $5 each in quantity and contain all the text information in the *Encyclopaedia Britannica*. A single CD-ROM disk can contain more text than the best *industrial-quality* line printer will print over its useful lifetime. A set of 20 of those disks would make an encyclopedia like nothing that ever existed: illustrations could include motion pictures and stereo. The article on space could include shots of *Apollo 11* taking off, and so forth.

It can't be long before this technology changes the way we look at and use information. Couple a CD-ROM disk drive to an Atari, and you have the potential for a powerful educational system: the greatest teachers and lecturers in the world complete with every demonstration tool they ever wanted. Want to explain the solar system? You can be a talking head for a while, then switch to color animated models, first of the planets in their orbits, with speedup at perigee and slowdown at apogee; color bars to show that the planets sweep out equal areas in equal times; and actual *Voyager* photographs of the planets themselves. Moreover, a section on integral calculus could use the planetary orbital animation to illustrate just what an integral is.

Now, true, the educational lobby will try its best to hang on to "credentialism" and will continue to insist that no fundamental changes be made in our present educational system. But no matter how hard educators drag their feet, this new technology can't be stopped. Not only the Library of the Month Club but the College Course of the Month Club have just become realities.

CD-ROMs will change the whole nature of scholarship. Even after all these years, only a handful of scholars have had access to the original text of the Dead Sea Scrolls; now, everything known about them, including

(continued)

video copies of not only the scrolls themselves but every word of commentary ever written about them, can be put onto a single CD-ROM disk and still have room for everything known about, say, the archaeology of Jericho. CD-ROMs don't become profitable until you can sell thousands of copies; but there's so much room on them that you can keep adding topics until the customer pool is large enough. It costs no more to manufacture a full CD-ROM disk than a partially full one. It shouldn't be long before even the smallest university can give its scholars access to primary sources previously available only in a few places.

As I was writing this, Dr. Paul Bohannan, dean of social sciences at USC, came over. It took him about 30 seconds to imagine new uses for CD-ROMs. Ethnographic data on cultures takes up enormous space. Much of it is irreplaceable, but it is also too expensive to be published in journals. The new computer memory-storage technology will change all that, and soon.

A few years ago, I said that by the year 2000, anyone in a Western nation who seriously wanted to would be able to get the answer to any answerable question. I'm now more than confident that I was right—except that it may happen much sooner than I thought.

FASTER THAN LIGHT

The best software item I discovered at COMDEX wasn't in a booth. Barry Workman had his Australian friend, Dave Moore, in tow. Both were eager to tell me about Moore's new Modula-2 compiler.

When we got back to Los Angeles, I understood why. They're calling it FTL Modula-2, and it's to every other Z80 Modula-2 what Turbo Pascal is to every other Pascal. FTL Modula-2 is *fast*; compiles to tight, fast-running code; and has an integral text editor. There are installation procedures for putting it onto every terminal Dave and Barry could get hold of; they even set it up to run on Zeke with his memory-mapped VDM board. They also have it running on the big CompuPro 286/Z80, and I am amazed to find that FTL Modula-2 on the Z80 compiles about as fast as Logitech Modula-2 on the 286.

FTL Modula-2 is reasonably priced; is not copy-protected; has a simple and sane licensing agreement; comes with good, clearly written, well-indexed documentation; and works. It wouldn't hurt to have a couple of other books, but you certainly can begin to write Modula-2 programs with nothing but the compiler and its documents; there are all kinds of source-code examples included.

FTL Modula-2 should do for the Modula-2 language what Turbo Pascal did for Pascal. If you have a Z80 machine and you're at all interested in languages, get FTL Modula-2. You won't regret it. Meanwhile, Dave Moore went back to Australia to write code generators to get FTL Modula-2 running on 68000, 8088, and 80286 machines. Watch for new developments.

TURBO!

Borland's Philippe Kahn has done it again. The new Turbo Editor Toolbox is the Turbo Pascal source code to just about anything you ever wanted a PCompatible text editor to do, along with a really excellent book of instructions on what text editors are and how to use the Toolbox to build a custom text editor.

This is the best deal for hackers since Turbo Pascal (which you must have to make the Turbo Editor Toolbox useful). If you're tired of text editors that don't do what you want; if you want features you can't get in a commercial editor; if you're at all curious about text editors, pull-down commands, and the like; you can't af-

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Borland International is a public benefactor. The company continues to pour out good, well-documented products at reasonable prices.

ford to be without this.

Do note that this is a product for programmers. I'm tempted to say advanced programmers, but that wouldn't be true. You do need to know Pascal in general and Turbo Pascal in particular, but, given interest and study, beginners can start with Turbo Pascal and the Turbo Tutor and work through the Turbo Editor Toolbox; at which point, they'll be advanced programmers.

Incidentally, Borland has a boxed set of Turbo tools that includes Turbo Pascal, Turbo Tutor, DataBase Toolbox, Editor Toolbox, Graphix Toolbox, and GameWorks. All together, this is the perfect present for the hacker in your life, and you don't need to wait until graduation.

The Turbo boxed set is useful for Modula-2 programmers, too. With Richard Gleaves's book *Modula-2 for Pascal Programmers* (Springer-Verlag, 1984), you can rather quickly translate much of the Borland source code into Logitech Modula-2 modules that run quite nicely on PCompatibles.

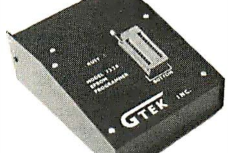
I've said this before, but I want to nail it down: Borland International is a public benefactor. The company continues to pour out good, well-documented products at reasonable prices. Philippe Kahn has proved that giving customers a better deal is not only fun, it's good business. I wish the rest of the industry would catch on.

Of course, Workman did catch on: the source code to the FTL Modula-2 compiler editor is included with FTL Modula-2, doing for CP/M what Turbo

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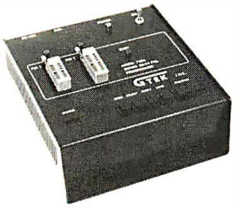
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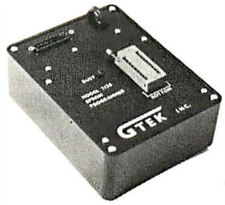




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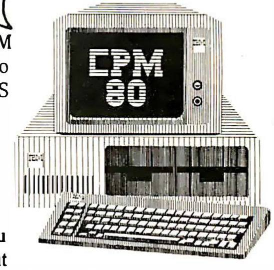
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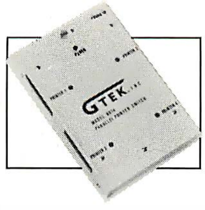
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Microsoft's Excel is easy to learn and sets new standards in business software.

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BEST OF 1985

Everyone else gives out Product of the Year awards, so I thought I'd do it too. The ground rule is that no matter how long it has been around, it's the year I started using it that counts.

As to how I choose them: it's purely subjective. Generally, my Products of the Year have to be useful to me in something I do; but I also look for products that look as if they'll greatly and beneficially influence the microcomputer revolution. I also tend to have lots of ties, rather than try to choose just one from a list of excellent products.

SOFTWARE

The business software of 1985 has to be Microsoft's Excel. The program is so darned nice that it overcomes much of my dislike of the Macintosh. Excel is easy to learn, but better, it's also easy to use. Best of all, you can easily get at Excel's powerful macro capability. Excel is what a spreadsheet ought to be and sets new standards in business software. Now if Microsoft will just get it onto machines with screens big enough to see...

In the word-processing category, there's a three-way tie and an honorable mention. Tied for best of 1985 are Symantec's Q&A, Borland's Turbo Lightning, and Living Videotext's Ready! idea processor. It's impossible to choose among these; they're all useful. Two are memory-resident. I suppose that one day the trend to memory-resident software will be halted by a really excellent multitasking operating system. Maybe this year?

(continued)

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All three of these programs are evolving. As I write this, I have on my desk Wayne Holder's newest spelling checker and thesaurus program that mates with Symantec's Q&A, and I hear persistent rumors that Symantec is adding an outline-processor capability as well. Q&A has enormous promise. By integrating the text editor and database, Symantec has greatly simplified life for new computer users. Symantec's chairman, Gordon Eubanks, has been in the microcomputer movement from the beginning and has a real feel for what we can and ought to do with micros. Of course, he's not alone: Living Videotext has Dave Winer, and Borland's Philippe Kahn has made his mark on this industry, too. Borland has already promised new database additions to Turbo Lightning.

The honorable mention is General Transformation Company's Beyond Compare, a file-comparison program. At $30, it's hard to beat for value. A file comparator is something you don't need every day, but when you need one, you need a good one—and you need it bad. I've long had one for CP/M. Beyond Compare is for PC-DOS, and it's excellent.

My final software category is languages and programming tools. Once again, there's a tie: Borland's Turbo Editor Toolbox and Workman's FTL Modula-2 compiler. I should also mention Logitech's Modula-2 compiler for the PC; it wasn't new in 1985, but the dramatic drop in price made it very nearly a new product. Good Modula-2 compilers at reasonable prices will get more people interested in the language, and since Modula-2 is logical and easy to learn, that will get more people involved in programming, which will do great things for the micro field. In their classic work *The Elements of Programming Style*, Kernighan and Plauger say repeatedly that the best way to learn good programming habits is to study good code. Both FTL Modula-2 and the Turbo Editor Toolbox give the programmer well-tested and useful source code. That's a giant step in the right direction.

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HARDWARE

There's no competition for most useful computer to arrive here in 1985: the Kaypro 286i PC AT clone has been in constant use. So far, we haven't found any PC programs it won't run. Certainly nothing else I've acquired this year has helped me as much. Rather than ignore the Atari 520ST and the Amiga, which are likely to have an enormous impact on this field, I've decided to rule them ineligible: after all, I've had them only a week.

As to accessories, there are so many! Symantec has a 256K-byte PC clock and memory board that's so cheap they practically give it away

(continued)

with Q&A. Plus Development has Hardcard for the PC; open the machine, drop it in, and have a 10-megabyte hard disk. I've been running my OmniTel Hayes-compatible 1200-baud internal modem in the Kaypro 286i, and, given my addiction to BIX, that modem is probably the equipment we use most here. Finally, there are two different boards that make the Zenith Z-100 about 98 percent PCompatible, making the Z-100 one of the most useful machines you can buy. I can't choose among all those, so I won't try. They're all great.

GAMES

The most intellectually impressive game to come out this year was Brøderbund's Ancient Art of War. I've still to win a game against a difficult opponent—the game allows the computer to simulate six different generals, ranging from Crazy Ivan, who has no sense of strategy at all, to Sun-tzu, who never makes a mistake—but the game is interesting enough that I keep trying.

However, for sheer time wasted, SirTech's Wizardry I wins hands down. I do not know what the fascination is, but the darned game keeps attracting me to one more expedition.

FOLLY OF THE YEAR

I had a lot of nominees for this one:

- IBM's new ROMs that make sure you're not running the AT too fast
- MacCharlie, a box that takes the marginally adequate Macintosh and tries to make a marginally adequate PClone out of it
- IBM's media blitz to sell the PCjr after announcing its demise last spring

However, the winner stands out by a mile.

Some years ago, a summer-hire programmer embedded a warning message into Microsoft's shell. The message was supposed to appear when the program detected an attempt to copy one of Microsoft's copy-protected programs. It said, "The tree of evil bears bitter fruit. Now trashing program disk."

Needless to say, there was no code that would actually harm the disk or do anything other than display that message, which eventually found its way into every copy-protected program Microsoft sells. Of course, it was inevitable: a user got a disk error while running a perfectly legitimate copy of a Microsoft program. The message appeared—and the user found garbage in his disk directory.

In Microsoft's favor, I have to say that once they knew, they scrubbed that message, and in fact they are now dropping copy protection entirely; but meanwhile, Folly of the Year goes to Microsoft, who didn't even know that silly message was in their products.

WINDING DOWN

As usual, I'm out of space long before getting to more than a fraction of the wonderful things people keep sending me. There seems to be absolutely no solution to the software-overload problem.

The book of the month is *The Mind's New Science: A History of the Cognitive Revolution* by Howard Gardner (Basic Books, 1985). I've become very much interested in the new cognitive sciences, which draw on the fields of philosophy, anthropology, mathematics, computer science, physiology, and psychology. This book is an excellent summary of what's been done and gives some indications of where the field is going. Don't expect too much: a great deal of what's past has been clearing out the sterile deadwood of behaviorism.

Gardner isn't alone in concluding that the "science of mind" is ready for its Galileo or Newton. My own view is that the task may be too big for any one scholar, and, as it happens, I have been working with a university dean, several professors, hackers, writers, students, and volunteers to use BIX to set up a new organization to integrate some of what's known and focus new research. In my judgment, the new communications tools and technologies are going to revolutionize the way we do science and will be at least as important in changing the world as the computer itself. More on this another time.

As I predicted, software for conferencing is beginning to pour in. I already have preliminary versions of programs that will call in, log on, capture my BIX mail and conference messages, log off, and then, while off line, sort and index them—all unattended. More are promised. It won't be long.

Aren't little computers wonderful? ■

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Gavilan Information, Anyone?

Dear Jerry,

I am one of the few purchasers of a Gavilan computer and have recently run into a hardware problem that requires attention. Unfortunately, most repairmen I have talked to indicate that it would be almost impossible to properly service the machine without a schematic or technical manual that could serve as a guide to the internal circuitry. Since Gavilan has filed for Chapter 11 and is in effect no longer in existence, I am unable to call them for help on this matter. Do you have an idea where I might find a set of schematics?

Jesse Martinez
POB 11284
Reno, NV 89510

Alexander Woollcott is said to have answered a letter by writing, "My dear sir. Oh, my very dear sir. Sincerely, . . . ," and I must admit I am tempted to do something similar here. I do know that David Ramsey of Corvus was somehow involved in the sales of some Gavilan machines after the company went west; but I think he never had the schematics either.

I expect, unless a BYTE reader can help, that you are doomed. You might also try BIX or another electronic communications system.

Owners of Otrona machines, incidentally, are not in a similar pickle. Spin and Pop (POB 6458, Denver, CO 80206) managed to get spare parts and schematics for the Otrona machines and can both service them and do the upgrades.

Wishing you well.—Jerry

Valdocs 2

Dear Jerry,

I'm a physicist and journalist who has dealt with computers since 1955. For several years, I have been giving nontechnical seminars worldwide on how to choose and use computers. I was an early Valdocs booster. I read all you've had to say about it and usually agree but still had great hopes for it. A quick survey indicated that a majority of my seminar attendees who purchased computers bought Epson.

I am now giving Valdocs 2 heavy usage. It has made great changes in my life, converting a calm, quiet technocrat into a raging, wild, frustrated maniac!

Why? When Valdocs 2 works, it provides the most efficient, free-flowing creative writing outlet I've ever experienced. It adds incentive to writing. But I have never yet completed an intense period of usage without a disastrous data loss!

I'm not alone. Earlier this evening, a well-known journalist spent two and a half hours crying on my shoulder via telephone for the exact same reason. The contrasting good and bad aspects are maddening. Writers with great seniority have quoted identical figures to me: While Valdocs works, they produce three times as much finished copy per unit of time as they did previously. But the psychological devastation of never knowing which story will be the next sacrifice on the altar of Valdocs is becoming too much for many of these writers. Typewriters, and even pencil and paper, are the writing instruments of their future.

Milton Mann
Evanston, IL

So what can I say? I agree with every word; Valdocs when it's working is great, if you don't mind that it's a bit slow.

My best advice is to try WRITE for your Z80; WRITE was designed by people fanatic on not losing text.—Jerry

70108 Microprocessor

Dear Jerry,

I stumbled over an interesting development in microprocessors that I feel is the start of a significant trend.

The October 1985 issue of *Radio-Electronics* carried an ad by JDR Microdevices. Among the specials was a $20.95 microprocessor by NEC, designated the μPD70108. What caught my eye was the statement that it was 8088 pin-compatible and used a superset of the 8088 instruction set. I ordered one and contacted the NEC technical representative for the user's guide. When both arrived, I found that I had more than I bargained for:

1. The 70108 is a high-speed CMOS device, drawing less than half the current of an HMOS 8088. It also has a standby mode that draws almost no current.
2. The 70108 has two internal data buses, which operate together to speed up some calculations. My normal AUTOEXEC.BAT file takes 34 seconds to load using an 8088 but only 32 seconds using a 70108 operating from the same 5-MHz crystal. And the 70108 will operate at 8 MHz.
3. In addition to being 8088 pin- and function-compatible, the 70108 has 8080 emulation-mode commands, which seems to mean that this chip will run 8-bit CP/M software as well as 16-bit (once someone figures out how to switch modes).
4. I don't know enough about assembly language to evaluate the additional instruction set, but it's there.

I installed the 70108 in place of the 8088 in my Heath H-100 three days ago and have found no reason to remove it. As far as I can tell, the 70108 can be installed anywhere a 5- or 8-MHz 8088 is used and will speed everything up by a few percentage points. I don't know about micros with 8087 math chips installed.

I consider this unusually significant for two reasons. First, it is a pin-compatible upgrade, which doesn't require the purchase of either a new microcomputer or board, and can be installed by anyone who can read static-electricity warnings and use a screwdriver. I expect that to become a trend. Second, this chip is of Japanese origin, and I expect that to be a trend as well.

If you decide to drop 70108s into your machines, I'd like to hear about it.

Michael A. Schulsinger
Springfield, OH

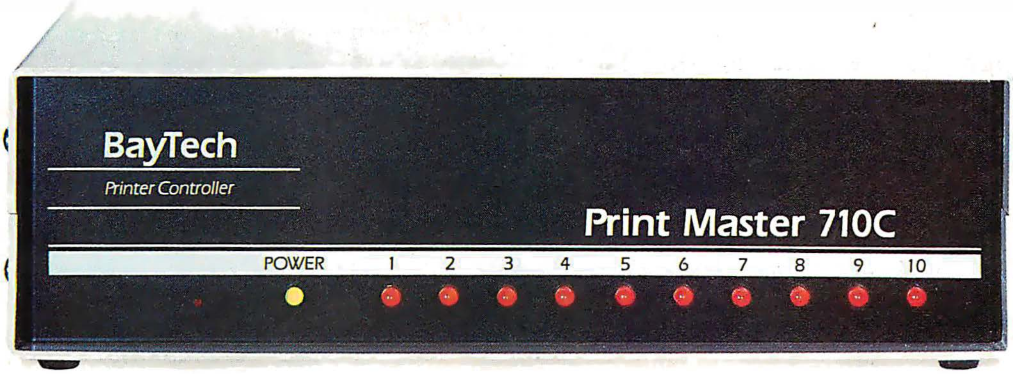
We have indeed used 70108s in both IBM PCs and Zenith PClones, with results similar to yours. We got the chips at a Heath/Zenith User Group meeting, but there are a number of sources. I haven't myself made any use of the 8080 emulation mode, but I've seen user group articles about doing that. Mostly, though, the decreased power consumption and heat in the computer is itself worth the modest cost of the chip.

Some hackers are making use of the 70108's ability to run with faster crystals, but I haven't tried that yet.

I expect you're right about the trends. —Jerry ■

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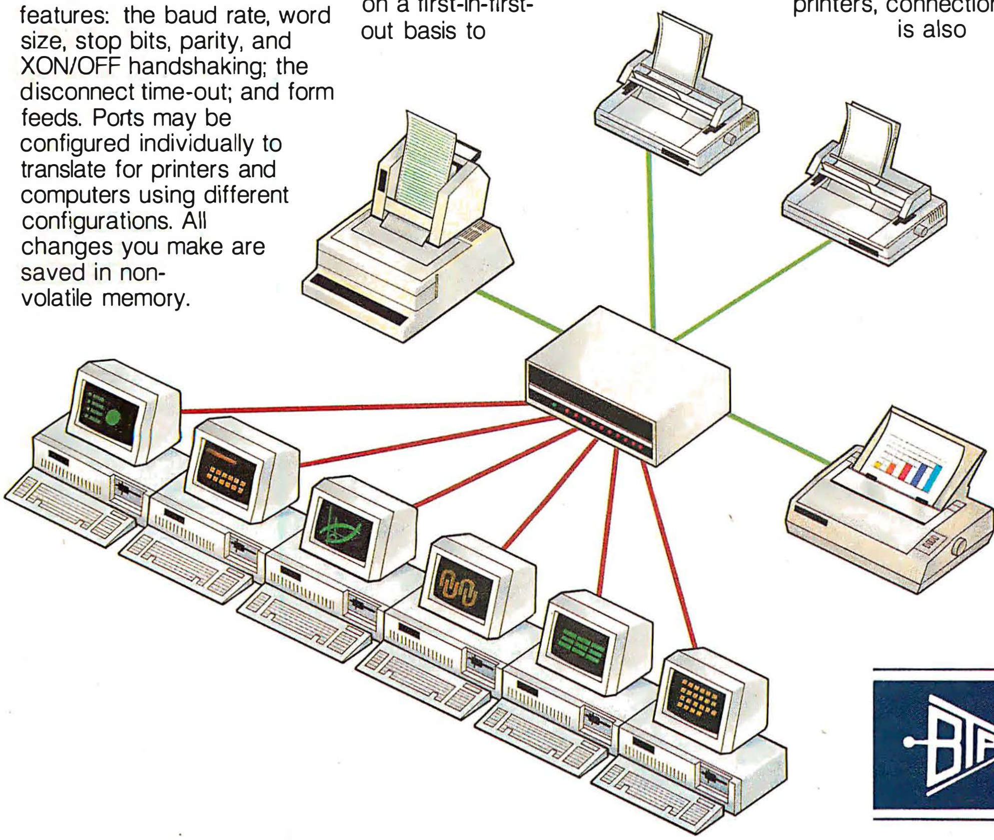
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Xenophilia

The high-performance, inexpensive XEN uses Microsoft Windows and SoftClone

BY DICK POUNTAIN

Apricot Ltd. is the U.K.'s largest indigenous manufacturer of business microcomputers. The Apricot story has been one of almost unblemished success since the design and manufacture of the first 8086-based Apricot computer in 1982.

Flying in the face of conventional wisdom, Apricot achieved a respectable share of the European market with a range of 16-bit machines that are IBM PC-compatible at the lowest possible level; they provide minimal generic MS-DOS support. That means they are scarcely compatible at all. Apricot's success—and consequent corporate wealth—has enabled it to pay some leading U.S. software companies to port their top-selling programs onto its machines. Hence, Apricot users can now run Lotus 1-2-3 and Symphony, albeit a couple of years later than IBM users. (You can contact the company at Apricot Ltd., Shenstone House, Dudley Rd., Halesowen, West Midlands B63 3NT in the U.K. and at Apricot Inc., 47173 Benicia St., Fremont, CA 94538 in the U.S.)

During the grim trade recession of 1985, it seemed at first as if Apricot was immune to the prevailing commercial distress. In the last quarter, however, Apricot suddenly announced a trading loss for the first time, due to poor sales of its portable computer and of its low-end (under £1000) machines with which the company had hoped to gain entry into the educational market. Announcing a change of tack back toward the high end of the business market, Apricot recently unveiled its answer to the IBM PC AT—the XEN (see photo 1).

In common with earlier Apricot machines, the XEN offers more performance than the PC AT does for substantially less money. A basic twin-floppy machine costs £2095 and a 20-megabyte Winchester machine costs £3095, to which you need to add at least £395 for a monitor (more for the fancier options). It is also one of the first machines to be shipped with Microsoft Windows as its standard operating environment. In addition, Apricot has announced that it will support Digital Research's GEM and XENIX for up to 16 users on the XEN, but not until later in 1986.

However, to the great surprise of the U.K. computer press, the XEN is still not architecturally compatible with the PC AT, despite its using the same 80286 processor. Most people had expected that in today's harsher market, Apricot would have symbolically "bent the knee" and modified the machine to run standard IBM programs, but it has not.

THE HARDWARE

Apricot has always been very strong on industrial design, and the XEN is without doubt the finest-looking machine to come out of the Birmingham laboratories. It has an angular "high-tech" look reminiscent of expensive artificial intelligence workstations. This impression is reinforced when the optional *paper-white* phosphor high-resolution monitor is used to give a display quality not far from that of a Sun or Apollo workstation. Despite its large memory and mass-storage configurations, the XEN has a much smaller footprint than an IBM PC, nevermind the gargantuan PC AT.

To achieve its small size, the XEN's designers left the power supply outside the main box; it sits on the floor near the wall socket, like those used on home computers. The unit is rated at 135 watts and is smart enough to adjust itself to supply voltage, provided this is either between 90 and 130 volts (as in the U.S.) or 180 and 260 V (as in the U.K.). It's housed in a louvered box about a foot long and has two sockets to supply 5- or 12-V direct current to the system unit and 120- or 250-V alternating current to a monitor.

Inside the system unit is a single-board 80286 microprocessor clocked at a brisk 7.5 megahertz. Combined with the zero-wait-state memory system, this permits performance over 60 percent better than the

(continued)

Dick Pountain is a technical author and software consultant living in London, England. He can be contacted c/o BYTE, POB 372, Hancock, NH 03449.

IBM PC AT (for processor-bound tasks). The XEN supports four channels of DMA with three more available as options; you can also fit an 80287 floating-point coprocessor as an option. An RS-232C and a Centronics parallel port are built onto the motherboard. The system unit is cooled by a fan that is about as loud as that in an IBM PC.

The machine I tested was the larger of the two standard configurations offered, having 1 megabyte of RAM on the motherboard, a single 720K-byte 3½-inch floppy-disk drive, and an internal 20-megabyte Winchester disk (of the latest 3½-inch type). The smaller configuration comes with 512K bytes of RAM and dual floppy-disk drives. All the memory is supplied in 256K-byte RAM chips.

You can expand the system in several ways. The hard-disk machine can accept a second internal hard-disk drive, making 40 megabytes in all, while the smaller machine can be field-upgraded to the hard-disk specification. The motherboard contains six expansion slots, and they accept small Apricot format cards. Four of these are available to expand the memory up to 5 megabytes (using four 1-megabyte cards) or to add an on-board modem; the other two are reserved for video cards. You can gain access to these slots by opening a small hatch cover (like a miniature Apple II), rather than by dismantling the whole case, and you can open it without even displacing the monitor.

On the right side of the system unit is a bus extension to which you can attach an optional card cage that accepts two IBM PC or AT cards. Since the XEN makes no pretense of emulating the IBM hardware, this unit is really designed only to hold some of the more exotic communications cards for a micro-to-mainframe connection. IBM display cards will not work in it because the XEN has a totally different display architecture.



Photo 1: *The new Apricot XEN 80286-based business microcomputer. It is shown with a 360K-byte 5¼-inch floppy-disk unit and an expansion box, which can house up to two IBM expansion cards; these units provide some compatibility with the IBM PC and the PC AT. The optional combination trackball/mouse and telephone are also shown. The XEN is seen running Microsoft Windows, which is its standard operating environment.*

The XEN supports a variety of display resolutions. Monochrome resolution is 800 by 400 pixels, which produces superb text quality and permits numerous "soft" text fonts to be displayed. Three monochrome monitors are offered—a choice of a 9- or 12-inch green screen, or the superb 12-inch paper-white unit I received. (Frankly, the paper-white unit is well worth the extra £150 it costs.)

There are two options for color. The higher resolution is 640 by 350 pixels in 16 colors (from a palette of 64), which is more or less equivalent to the IBM Enhanced Graphics Adapter. However, the XEN video card for this subsystem contains graphics-processing hardware (implemented by gate arrays) that performs fast vector and arc drawing and area fills. It appears to offer a much higher performance than the IBM system; I wasn't able to run any benchmarks to confirm this, but the demo program looks as blindingly fast as an Amiga.

The lower resolution for color is the old faithful 640 by 200 pixels in 4 of 16 colors and is not supported by any fancy hardware. Different 12-inch monitors must be used for these two different-resolution color modes.

Apricot machines have always been well built, except for the keyboards, which I have found rather dead in feel and cluttered in layout. The keyboard problem has been remedied on the XEN; it has one of the best keyboards I have ever used. The feel is excellent; it has both a light touch and a positive click—a hard combination to achieve. All the keys are in sensible places, and truly massive Shift, Return, and Control keys make touch-typing a pleasure. The layout is different from previous Apricot designs: It has a separate pad for cursor-control and numeric keys, provides all the IBM editing keys like PgUp and PgDn, and it also has separate cursor keys (no Num Lock required). Scroll Lock and Caps Locks have red LED indicators.

Apricot has revived the *microscreen* for the XEN keyboard, a single-line LCD built into the keyboard that shows the date and time by default.

(continued)

Unlike previous Apricot versions, the microscreen is now backlit by a blue electroluminescent panel so that you can read it under all lighting conditions. Beneath the microscreen are six function keys with red LED indicators; conscientious application vendors can program these to display their assignments on the LCD. In addition, there are 10 IBM PC-style function keys along the top of the keyboard, which have legends such as Help, Repeat, Print, Calc, and Undo stenciled below them. This is not such a good idea, since they don't perform their labeled functions at the Microsoft Windows executive level, and in Windows Write they support functions different from the labels. Some applications do support the labeled keys, though. WordStar 2000 supports most of them—the Calc key, for example, turns the microscreen into a desk calculator complete with memory functions.

I also received an Apricot trackball/mouse, which connects to the keyboard unit by a thin fiber-optic cable. Although you can use it as a mouse by tilting it forward until the large ball contacts the table top, it is more usually used as a trackball by directly manipulating the ball, which saves a lot of desk space. I found it easy enough to use but less convenient than a conventional mouse, since it tends to tire your forefinger.

I tested Apricot's speed claims for the XEN by running the Sieve of Eratosthenes and Disk benchmark tests in interpreted GW-BASIC. The results are shown in table 1. (The AT benchmarks appear in Alan Finger's review "IBM PC AT," May 1985 BYTE, page 270.) The XEN figures are very fast; the Sieve runs 72 percent faster than on a PC AT (the higher clock rate can only account for part of this), while the floppy-disk access is 48 percent faster.

Windows

The XEN offered me a first opportunity to use the released version of Microsoft Windows. XEN comes bundled with Windows (complete with clock, notepad, calendar, calculator, card file, asynchronous-terminal program, and one game), the Windows applications Write and Paint, and GW-BASIC. You also get a software IBM ROM BIOS emulator that will run completely well-behaved IBM PC programs rather slowly. I was not able to test this latter feature since the optional, external, 5¼-inch floppy-disk drive was not available at this writing.

I think Windows was well worth the two-year wait and is the nicest environment I've used so far. It is fast and easy to navigate around. When you want a new window, it comes up in a flash—none of that annoying Genie-out-of-the-bottle stuff that happens on Macintosh and GEM—and on a hard-disk XEN, the little hourglass isn't on the screen long enough for you to get sick of it.

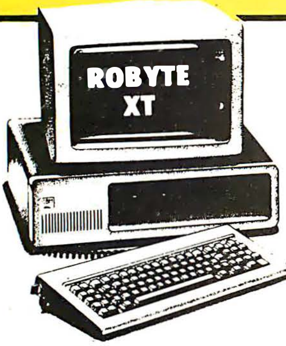
Purists may scoff at the tiling system that Microsoft adopted instead of full overlapping windows, but it does precisely what you want it to do, and quickly. After all, who cares about the hidden part of an overlapped window? It's what you *can* see that's important. To me, overlapping windows only make sense if they can be summoned and dismissed *instantly* as in SideKick. Windows always lets you

(continued)

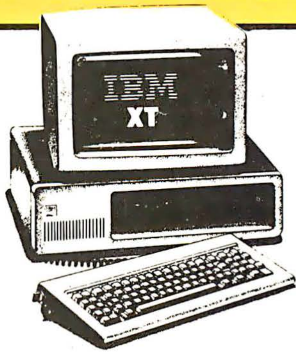
Table 1: *The XEN's speed-test results (in seconds).*

	XEN	IBM PC AT
Write a 64K-byte sequential file to floppy disk	17.5	26
Read a 64K-byte sequential file from floppy disk	16.5	24
Write a 64K-byte sequential file to hard disk	10	
Read a 64K-byte sequential file from hard disk	9	
One iteration of the Sieve of Eratosthenes	46.5	80

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choose between the keyboard and the mouse for control, and if you are already familiar with MS-DOS, you can use your knowledge to its full effect.

The multitasking aspect of Windows is excellent. You can switch from one application to another in the time it usually takes to move the cursor two inches—faster than Macintosh, even with Switcher.

Windows Write looks great on the high-resolution paper-white monitor and seems to be a plain but likable word processor. It's basically a cut-down version of Microsoft Word, without virtual memory and fancy formatting features like the style sheets. Nevertheless, I was able to get 47 pages of text into the XEN's hefty memory, more than enough for many people.

Windows has an unusual way with fonts. When you tell Windows what printer you are using, it automatically loads the fonts that printer supports; if you select a different printer halfway through writing a document, the whole text may change to a new font. For most printers you have a choice of Courier, Helvetica, or Times Roman print in various sizes, but the large sizes are just blown-up versions of the smaller ones (rather than separate bit maps), and they can look somewhat clunky.

Windows Paint is another MacPaint clone, although it has a few extra features, and it too looks terrific on the paper-white screen. Cutting from a drawing into the clipboard allows you to transfer pictures into documents, just like the Mac. Unlike the Mac, though, Windows lets you run Paint and Write in two adjacent windows and move a drawing right across from one to the other.

IBM PC Compatibility

Despite its obvious virtues, the XEN will probably succeed or fail on the issue of IBM PC compatibility. This is not necessarily just, but it is reality. Apricot has previously paid lip service to PC compatibility, providing either the minimal level of generic MS-DOS support or grossly inefficient software emulation. This could have been seen as a reasonable expression of commercial and national pride in 1982; now it seems like hubris.

With the XEN, Apricot is going further than ever before toward the IBM standard. In December 1985, the U.K. trade press was humming with rumors that Apricot intended to buy an IBM-like ROM BIOS from Phoenix Software, suppliers to the IBM-clone industry. If this were true, it would entail extensive modifications to the XEN motherboard, which in turn would involve either a recall or at least a relaunch.

I'm assured by the highest-level sources inside Apricot that this is not going to happen. Instead Apricot will rely upon a novel software solution to compatibility called SoftClone. This program is produced by the California software house Control-C Inc., and it is rather more than the usual kind of software emulator.

SoftClone

SoftClone actually *modifies* the code of IBM PC and PC AT programs. Specifically, it traps badly behaved direct memory accesses in such programs and patches the code with calls to the equivalent addresses in the XEN. Programs like SideKick that write directly to the IBM video buffer are modified to write into the XEN buffer, and so on. Well-behaved programs that only use legal BIOS calls and software interrupts are dealt with by a soft ROM BIOS emulator, which redirects the calls to their equivalents in Apricot's own BIOS 3. In searching for a descriptive label for SoftClone, the best I can manage is cross-disassembler-assembler. As an adjunct to SoftClone, Apricot plans to produce an external 5¼-inch floppy-disk drive that will read all the various IBM disk formats; I have seen a prototype working.

When does this code modification occur? Every time you run a program. To run an IBM PC program, say WordStar, on the XEN, you invoke it with the command line IBM WS at the A> prompt. IBM.EXE is the SoftClone

(continued)

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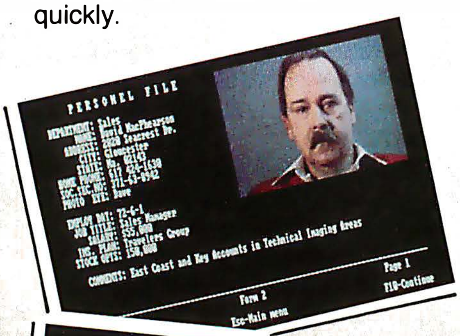
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Inquiry 55

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program that loads, patches, relocates, and runs WordStar, delayed only as long as it takes to display Control-C's fleeting copyright message. SoftClone only modifies the memory image of WordStar; the code on the disk remains unaltered. The changes shouldn't compromise the program's performance at all and should, in fact, enhance it wherever the XEN executes more quickly than the IBM does.

To accomplish the patching, SoftClone requires a short file for each application called, for example, WS.AD (WordStar Application Descriptor), which contains details of all the poorly behaved parts of the program. Initially, Apricot and Control-C will prepare these AD files for various popular packages, but eventually they hope to persuade application vendors to produce AD files for new releases as a matter of course. The effort involved in producing an AD file is quite small for an application's author, who is familiar with the source code, much less than performing a full port from one system to the other. However, the effort that would be required of a user is out of the question, even for one with programming experience.

Apricot bravely loaned me a very early preproduction version of SoftClone for this report, along with IBM versions of SideKick, WordStar, Lotus 1-2-3, and MultiMate, and their corresponding AD files. WordStar and MultiMate worked perfectly without any apparent speed degradation. Lotus 1-2-3 worked properly, although the display attributes on the paper-white monitor were rather odd. (Solid-color blocks, including the cursor, appeared as thin black underlines.)

The SideKick AD file was clearly not finished, as several of SideKick's functions (e.g., moving and contracting windows) didn't work. All the accessories could be summoned from inside the other IBM programs, but not from within Windows applications. Even so, this was the most impressive demonstration; you wonder how it can be done at all, since SideKick is about as IBM-specific as you can get. It was also the only program that

SoftClone modifies only the memory image, not the disk file.

showed any performance degradation, and that was mainly in the speed of updating the 25th screen line (the menu line). I suspect that the SK.AD file was redirecting this through a DOS output call rather than through direct video, and it suggests that the proper implementation of AD files could have a critical effect on SoftClone's success.

Overall, I was convinced that the SoftClone concept works and with a minimal degree of inconvenience to the user. There are still some unanswered questions: Can it be integrated into Windows (I only tried it directly from DOS), and what happens with copy-protected programs?

SoftClone may breach some forms of copy protection, but that depends on whether or not you can save the patched memory image and use it. I couldn't find a way to do so, but a serious hacker might.

CONCLUSIONS

I liked the XEN. It's compact, pretty, fast, a pleasure to use, and keenly priced. With the optional paper-white monitor, it's like having a cross between a Macintosh and a PC AT, but it's faster than either one. The high-resolution color-graphics version should do wonders for packages like AutoCAD.

Whether or not SoftClone proves to be a full answer to IBM software compatibility remains to be seen. I found the signs encouraging, as it seems to work technically. A potential problem lies with the backlog of IBM software; although the top 20 programs are sure to be catered to, it's unlikely that some of the older and more obscure ones ever will be. The ultimate question is, How badly do you want to run lots of old IBM programs? For first-time buyers, however, this shouldn't be much of an obstacle. ■

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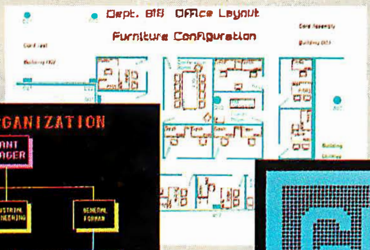
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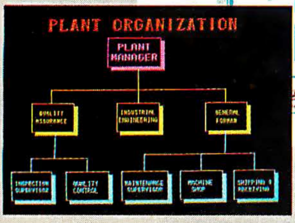
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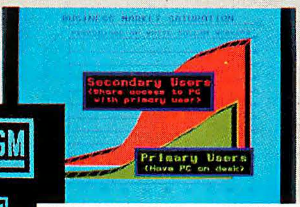
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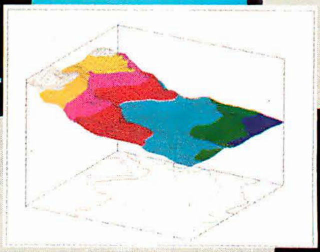
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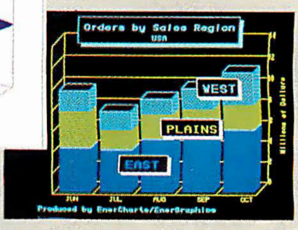












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Clearing the Backlog

TML Pascal
Mac C
M-Disk
Soft Spool
MichTron Utilities
Mudpies
Flip Side
Mirage
DEGAS
Deluxe Paint

BY BRUCE WEBSTER

Okay, okay, so I lied. Yes, last month I said that this column would have lots of tables with specs and benchmarks comparing the Macintosh, the Atari 520ST, and the Amiga. However, the planned announcements of the Atari 1040ST and the Macintosh Plus in January (it's late December as I write this) convinced me to put things off a month, in hopes of having specs and—just possibly—benchmarks for both. Nothing worse than outdated information, eh?

So what am I going to write about this month? If you could see the pile of software that has been accruing for the past few months, you wouldn't have to ask. However, time and volume are going to keep me from doing too comprehensive a job right now.

PRODUCT OF THE MONTH: TML PASCAL

Hallelujah! Tom Leonard has done in six months what Apple couldn't do in more than two years: produced and shipped a native-code Pascal compiler for the Macintosh that allows full access to the Toolbox and OS routines (including AppleTalk and MacinTalk). Tom's success is further evidence convincing me that Apple's failure was a deliberate marketing decision to encourage sales of the now-defunct Lisa/Mac XL. Unfortunately, all it encouraged was the de facto standardization of C as "the" programming language on the Mac. While I have nothing personal against C—why, some of my best friends use it—the Macintosh (in the form of the Toolbox, OS, and *Inside Macintosh*) assumes Pascal as the standard development language, and working out the differences between the two causes headaches for both compiler writers and programmers using C. Believe me, I know.

Anyway, Tom has developed and is now shipping the MacLanguage Series Pascal compiler through TML Systems. I received version 1.0 a few weeks back, and a new version (with a number of enhancements) is being prepared. The package comes with a 120-page manual, which contains both the user's guide and a reference manual, and two disks. The first disk—Pascal 1—contains stripped-down system files (in other words, it's bootable), the Pascal compiler, an editor (Bill Duvall's), a linker (the same one found in the Macintosh 68000 Development System [MDS]), and the RMaker and Font/DA Mover programs. The second disk—Pascal 2—has the necessary library and include files, as well as 11 example programs, some of which are direct adaptations of the Lisa Pascal examples that Apple has been distributing for so long. The entire package sells for $99.95, is not copy-protected, and has no licensing fees.

To use TML Pascal, your Mac must have at least 512K bytes of RAM—if it doesn't, you shouldn't be trying to do program development on it. Also, an external disk drive is highly recommended, that is, essential, for any serious work. If you have a new Macintosh Plus with its 800K-byte drive, you could get by with just one. (I personally recommend a 2-megabyte Mac with a hard disk, but then again, I'm spoiled.)

Use of TML Pascal is straightforward and quite familiar to anyone who has used the MDS assembler, Consulair C, etc. With the editor, you create your program text. The Transfer menu then lets you compile your program without having to exit to the desktop. The compiler itself is fast, running at about 1200 lines per minute off a hard disk (MacBottom). Errors, if any, are displayed on the screen and also directed to a separate text file; you then use the Transfer menu to get back to the editor. Once your program compiles correctly, you use Transfer to go to the linker, which is also relatively speedy. If your program links correctly, it will then appear on the Transfer menu, and you can execute it.

The Pascal implementation is fairly good, although a little restricted in places. For example, version 1.0 allows sets to have only up to 32 elements. Leonard has gotten a lot

(continued)

Bruce Webster is a consulting editor for BYTE. *He can be contacted c/o* BYTE, POB 1910, Orem, UT 84057, *or on* BIX *as bwebster.*

of flak about this from programmers (like me) who use set of Char heavily, and he promises that it will be fixed for the version 2.0 release. Likewise, the current implementation doesn't let you pass functions or procedures as parameters, though you can use the "@" operator to get the address of the entry point of a procedure or function. Beyond those restrictions, TML Pascal looks a lot like Lisa Pascal; Leonard's goal is to make it as much like Lisa Pascal as he can.

The extensions—none too extensive—tend to follow Lisa Pascal, which in turn follows UCSD Pascal. UCSD-type strings are implemented, with the standard procedures and functions. The InLine procedures and functions from MacPascal are also implemented, which allows easy conversion of routines. Following Turbo Pascal's lead, Read and Write can be used on files of records; unlike Turbo, the standard Get and Put routines are also implemented and can be used instead. For memory management, New, Dispose, and MemAvail are used; the HeapResult function lets you get the resulting code from the memory manager, just as the IOResult function lets you monitor the results of I/O operations.

TML Pascal offers a plain-vanilla mode for programmers inexperienced with the Macintosh. If you put (Input,Output) in your program statement, TML Pascal will automatically set up a window for you; will handle all calls to Read, Readln, Write, and Writeln; and will give you access to the QuickDraw routines as well. Be warned, though, that the Write and Writeln routines are fairly slow compared to the regular Mac text routines.

The compiler produces two types of output files: .ASM and .REL. The .ASM files are 68000 assembly-language source code and are compatible with the Apple MDS assembler. The .REL files are relocatable object-code files used by the linker to produce the final executable code. The compatibility with MDS, together with EXTERNAL declaration of procedures and functions and the $U compiler option to specify library files, lets you easily write assembly-language subroutines for your Pascal program, assuming you have MDS. And, if you do, you can use the .ASM files to hand-optimize the code the compiler produces.

As a test of TML Pascal, I decided to convert the StarMap program that I originally wrote using MacAdvantage, a UCSD Pascal derivative (see "New Perspectives on Nearby Stars," July 1985 BYTE, page 106). The conversion was surprisingly easy and consisted mostly of removing some of the work-arounds that MacAdvantage uses to interface with the Mac (the Locate function, etc.). There is a definite speed improvement, though it's not dramatic, since the program tends to be either waiting for user I/O or calling Toolbox routines. Also, it's become much easier to define application and document icons in the resource file, something I never could get MacAdvantage to do.

TML Pascal is by no means a finished product. Some bugs undoubtedly do exist, though I've found only one

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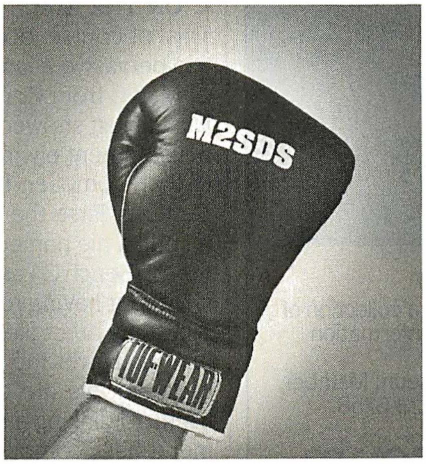
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FIBONACCI	*0:53.49*
30X30 MATRIX (8087)	*0:08.84*
FP OPERATIONS	*0:27.56*
FP OPERATIONS (8087)	*0:01.97*
SYNTAX CHECKING EDITOR	*YES*
MULTIPLE WINDOW EDITING	*YES*
EDITOR FILESIZE LIMIT	*MEMORY SIZE*
COMPILE ERROR CALLS EDITOR	*YES*
LINKER	*YES*
PRODUCES .EXE FILES	*YES*
EXECUTABLE CODE SIZE LIMIT	*DISK SPACE*
DOS ACCESS FROM EDITOR	*YES*
DOS ACCESS FROM PROGRAMS	*YES*
8087 SUPPORT STANDARD	*YES*
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Source: Software Resources, Inc. Sieve program from BYTE, January 1983. Fibonacci program from Dr. Dobb's Journal, February 1985. Matrix program from BYTE, October, 1982. FP Operations program from BYTE, May 1985. M2SDS with or without 8087 uses 8-byte accuracy. Programs compiled with all checking options on. All tests conducted on a standard IBM-PC/XT with 512K of memory and an 8087 math coprocessor.

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minor one so far. Also, Tom is planning on lots of improvements and extensions. TML Pascal has now become my standard development language on the Mac and will probably remain so for the foreseeable future.

C ON THE MAC

This, of course, doesn't mean I've given up on C. It's just too pervasive a language to ignore. Besides, version 4.01 of Mac C from Consulair Corporation (a.k.a. Bill and Ann Duvall) just showed up, easing the pain of learning C. The development environment is similar to that of TML Pascal (editor, compiler, linker, RMaker), with a few notable exceptions. First, the Transfer functions are more intelligent. If I edit a file named BENCH.C, the Transfer menu will give me "C Bench.C" as one of the options. So I can compile it without having to specify the filename. If I want to compile some other file, I simply close BENCH.C, and the Transfer menu gives me just "C" as an option. Second, the Exec program lets me do simple batch processing, which is useful for linking a number of .REL files. Third, the Transfer menu has "compile and go" and "link and go" options, which help cut down the number of steps during the compile-link-run cycle.

Mac C maintains a certain amount of compatibility with the Apple MDS assembler. You can use the Mac C linker to link in .REL files produced by MDS, but you can't use the MDS linker to link in .REL files produced by Mac C. However, since Mac C contains its own assembler (for both in-line and separately assembled routines), and since the Mac C linker is an "intelligent" linker (copying in only the code needed instead of the entire library), you don't really need MDS at all.

Mac C comes with four disks, three manuals, some update sheets, and a hefty price tag of $425. However, of all the C compilers on the Mac that I've used (including Megamax, Aztec, and Hippo), I prefer Mac C. It's what I'll be using from now on...when I'm not using TML Pascal.

To help me along with Mac C, a close friend of mine—Frank Boosman—gave me a book for Christmas: *Using the Macintosh Toolbox with C*. It's written by Jim Takatsuka, Fred Huxham, and David Burnard and published by Sybex at $22.95. The book is thick (more than 500 pages), has lots of sample code, and, from what I can tell, does *not* require that you own *Inside Macintosh*. Best of all (for my purposes, anyway), all the examples are written using Mac (Consulair) C, though the authors say they tried to make the code as compiler-independent as possible. The book has already solved one problem that was plaguing me in a benchmark program and, I suspect, will make life much easier for me. If you're going to program in C on the Mac, this book is probably worth owning.

ATARI 520ST SOFTWARE

Many programs for the 520ST have shown up in the past few weeks. In terms of sheer numbers, MichTron Inc. seems

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to be the winner. Five packages have shown up so far. The three most important are all system utilities written by Timothy Purvis. M-Disk is a RAM-disk package for the ST, which I haven't bothered to use yet since I still don't have TOS/GEM in ROM (and so have only about 256K bytes of RAM free). It should be great on a 1-megabyte ST, though. Soft Spool is a printer spooler to let you quickly complete a printing job and get back to work while the document is still printing. It uses a RAM buffer, so again this would work best with an ST with TOS/GEM in ROM. MichTron Utilities has two programs: a disk editor, which lets you view and change any byte on a disk, and a disk-copy program. The last two, Mudpies and Flip Side, are games; Mudpies is a cute but uncomplicated arcade game, while Flip Side is an ST implementation of Reversi. (Incidentally, Flip Side works with both color and monochrome monitors, while Mudpies works only with color.)

Mirage Concepts Inc. has two products out under its Holmes & Duckworth product line: Forth and Toolbox. I freely admit that I have used the Forth only briefly—I've had too much else to worry about the past few weeks to wrench my mind back into the RPN (reverse Polish notation) mindset—but the documents (55K bytes, distributed on the disk) give me the feeling that this was written by the programmers to satisfy themselves and so is probably a decent implementation. I've played around a little more with Toolbox, which has five programs in it: a disk editor (file or track/sector); a memory editor; a deleted-file-recovery program; a format-and-copy-disk program; and a directory-print program (seems there's no easy way to get a complete directory listing on the computer from GEM). In short, these are five very useful programs for anyone digging into the guts of the ST. All programs work with both monochrome and color monitors.

The best of the ST software so far is DEGAS, which stands for Design and Entertainment Graphic Arts System. Briefly put, it's painting software. Written by Tom Hudson and published by Batteries Included, DEGAS is the perfect "What does it do?" program for the 520ST. The user interface is simply a screen full of labeled buttons, so you don't have to do any icon decryption. The left button on the mouse lets you select buttons or perform actions; the right button switches you instantly between the buttons and your drawing.

DEGAS is full of features: points, lines, shapes (frames and solids), brushes, fill patterns, shadows and mirrors, and a lot of "design your own" power (including a separate font editor). Response time is fast, the manual is well written (but largely unnecessary—a tribute to the program's user interface), and it's just a great program. Best of all, it works on both color (16 colors from a palette of 512) and monochrome monitors, which a lot of ST software (including the public-domain painting program NeoChrome) won't.

The easiest way to put it is this: If you own an ST, you should buy DEGAS. And please *buy* it. The folks at Bat-

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teries Included were trusting enough not to copy-protect DEGAS and sensible enough to sell it for a fair price ($39.95). Please don't abuse that trust by getting it from a friend or letting a friend pirate your copy. And, no, I have no connections whatsoever with Batteries Included or Tom Hudson; I would just hate to see them both get ripped off by a bunch of thieves.

Amiga Software

As mentioned last month, Amiga software has just started to hit the shelves. In the past week, I've received about a dozen programs, all coming from just two publishers: Electronic Arts and Lattice.

As with the ST, the best Amiga program so far is a painting program: Deluxe Paint, written by Daniel Silva and published by Electronic Arts. Deluxe Paint is reminiscent of MacPaint—a menu bar across the top, icons along one side—but there's a big difference: color. And lots of it.

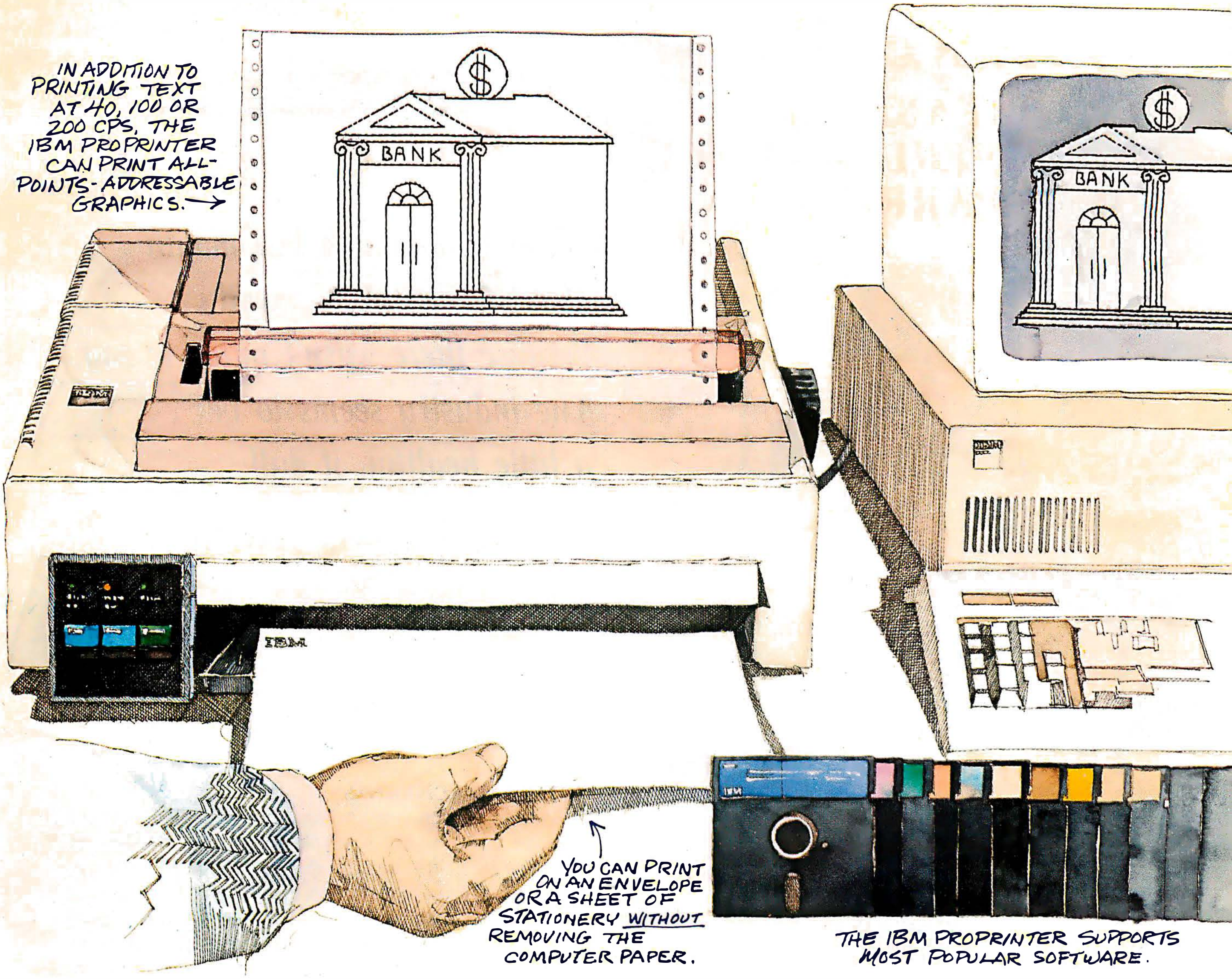
What really makes Deluxe Paint stand out are its features. Let's start with the color palette. In low-resolution mode (320 by 200 pixels), you can have 32 different colors (out of a possible 4096). Like DEGAS, you can individually adjust each color. But the palette's functions don't stop there. You can select any two colors on the palette and have it automatically generate a set of intervening colors. For example, if color #5 is pure red and color #15 is pure green, the spread function will turn colors 6–14 to shades that go from red to green—in this case, passing through orange and yellow along the way. I was able to easily generate a "rainbow" palette by creating the classic rainbow colors (red, orange, yellow, green, blue, indigo, violet) at regular intervals, then using the spread function to create intervening shades. Like DEGAS, you can set up a range of colors to cycle through; unlike DEGAS, you can define up to three different cycle ranges, each with its own speed.

As for painting, you have most of the tools found in MacPaint and DEGAS—like lines, filled and framed shapes, etc.—and quite a few found in neither, like the ability to do smearing, shading, or blending of the colors. You can grab any rectangular portion of the screen and use it as a brush. You can save and load brushes, which gives you an effective "clipboard" for saving chunks of pictures.

Comparing DEGAS (on the ST) and Deluxe Paint (on the Amiga) isn't easy, if simply because they are on two different computers. I prefer the two-screen user interface of DEGAS; it's easier to learn and a bit less cryptic. Deluxe Paint, on the other hand, has significantly more capabilities and options. Just about everything that DEGAS lets you do, Deluxe Paint lets you do in more ways and with more options, though there are a few things that DEGAS does better (or that Deluxe Paint just doesn't do). And like DEGAS and the ST, Deluxe Paint is a program you should buy if you own an Amiga.

Three of the remaining EA programs are games: Seven Cities of Gold, One on One, and Archon. Unfortunately,

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I didn't say much last month about COMDEX, mostly because there wasn't much to say. The industry seems to be a little healthy, if dull.

all three require a joystick, or at least work a heck of a lot better with one. More on these once I can scrounge up a joystick. The remaining EA program, Financial Cookbook, will probably get covered in a later column; I have an aversion to financial software that I must overcome first.

The software from Lattice is all geared toward development (i.e., a C compiler, a "Mac Library," and so on). I'll report more on this next column, since I'll probably convert all my benchmarks over to it.

NOTES AND COMMENTS

I didn't say much last month about COMDEX, mostly because there wasn't a whole lot to say. The industry seems to be a little healthy, if dull. The three most interesting things I saw were Atari's booth, which was crowded with third-party software displays; Commodore's booth, which was noteworthy in that it didn't exist; and the Levco 2-megabyte Monster Mac upgrade being shown in (of all places) the Apple booth. The latter was remarkable, given Apple's past attitude toward third-party memory upgrades; it also gives me hope for Apple.

The Mac Plus and the Atari 1040ST should both have been announced by now. The two machines are remarkably similar: 1 megabyte of RAM; a built-in double-sided 3½-inch disk drive; high-resolution monochrome monitor; a large ROM (128K bytes for the Mac Plus, 192K bytes for the 1040ST); 68000 processor; mouse; large keyboard with cursor keys and numeric keypad. The big difference is price: $2495 for the Mac Plus, $995 for the 1040ST. And, of course, the 1040ST has built-in color graphics and a faster clock speed. Some of you may be asking yourselves, "Why does the Mac Plus cost so much more than the 1040ST?" Good question. Wish I knew the answer.

Speaking of the ST. . . Atari says that with the introduction of the 1040ST, the 520ST will be unbundled and sold through the mass market (K-Mart, etc.) for $299. Of course, since it's nearly impossible to hook up anything but an Atari monitor to it, and since the machine is basically useless without a disk drive, the cost for a working system (monochrome) will be about $700. You're probably better off spending the extra bucks and just getting the 1040ST. Also, my memory may be playing tricks on me, but didn't Jack Tramiel spend most of 1985 swearing up and down that he was *not* going to sell the ST through the

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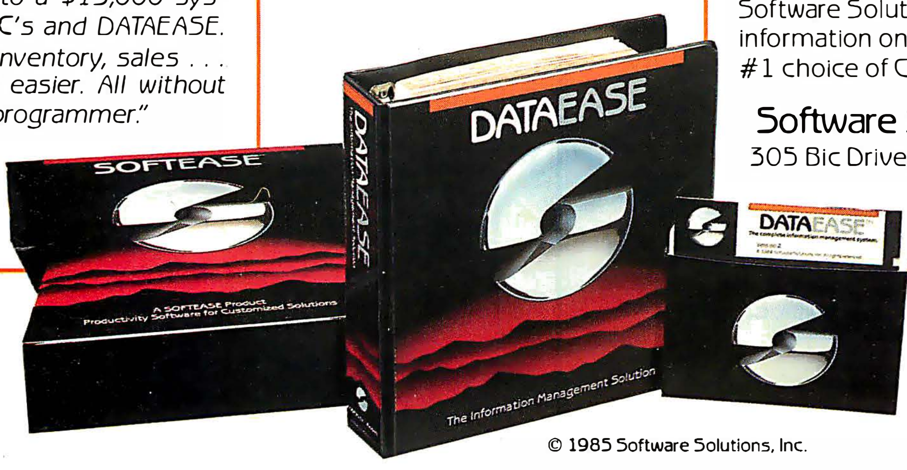
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mass market? I wonder how dealers are going to react to all this.

Coming Attractions

Okay. Next month for sure, the benchmarks on the Mac, the Amiga, and the 520ST. . . and, if I can, on the Mac Plus and the 1040ST as well. Maybe some more software reviews—I've got a stack of Mac and IBM software I haven't touched yet. And whatever else comes this way. Until then, see you on the bit stream. ■

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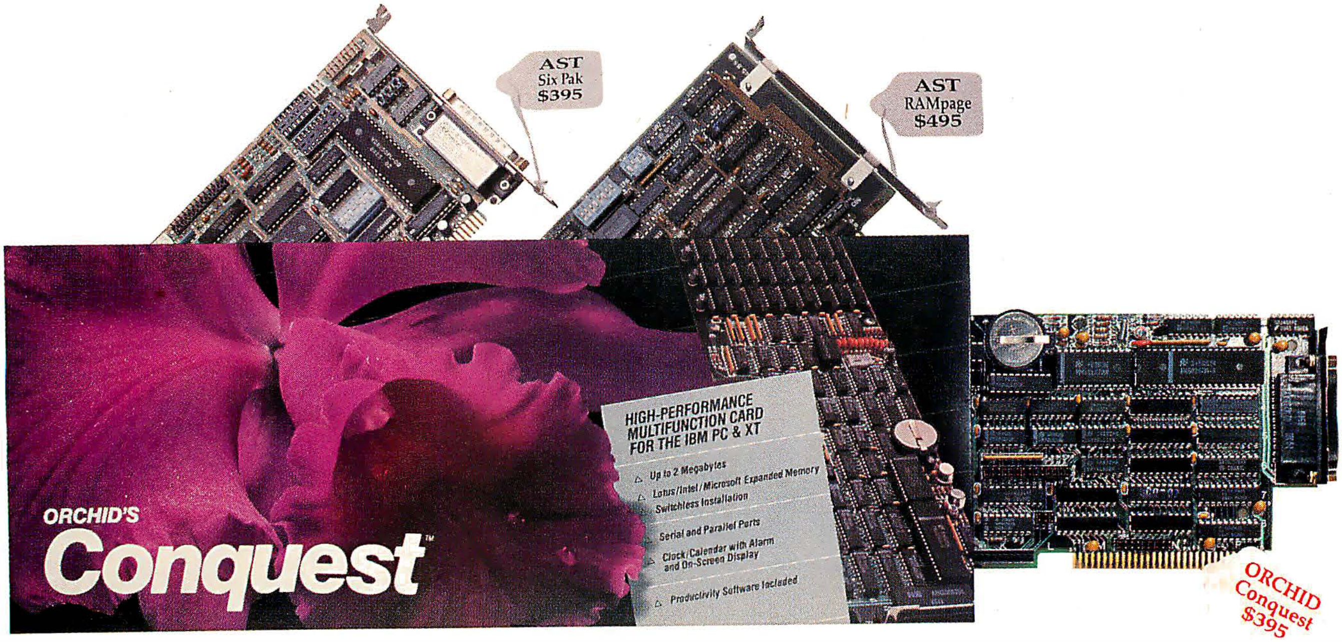
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A Couple of Winners

Mirror and Framework II

BY EZRA SHAPIRO

I feel a little embarrassed this month. I wanted to find some awful program to expose, some dire warning to issue. Instead, I'm staring at a mass of complimentary adjectives. But these two programs are the first I've encountered in a while that I've actually begun using in my day-to-day routine. I suppose I'll have to wait until next month to develop my reputation as a hard-nosed trasher of software.

SUPERCLONE

For 50 bucks you can buy **Mirror** (SoftKlone Distributing Corp., $49.95, 1210 East Park Ave., Tallahassee, FL 32301, (904) 878-8564), a telecommunications program for MS-DOS machines that looks like Microstuf's Crosstalk XVI, acts like Crosstalk XVI, and uses preexisting Crosstalk XVI parameter and script files. [*Editor's note: Microstuf has filed suit against SoftKlone on charges of copyright infringement for damages in excess of $1 million.*] Since Crosstalk costs more than twice as much even when discounted, this is good news if you were about to plunk down your cash for a copy of Crosstalk. But what if you already own a telecommunications package? This is all a big yawn, right?

No, wait. There's more to it than that! I've deleted my Crosstalk files and plugged in Mirror, and I'm not the sort of person who throws out trusted software without good cause. I've got to have *proof*, and here it is.

File-transfer protocols: Crosstalk supports only ASCII (text) transfer, XMODEM (with checksum error detection), and Crosstalk's own batch transfer. Mirror does all that and adds Kermit, MITE/Framework batch XMODEM, Hayes Smartcom, *and* a choice of either checksum or cyclic redundancy error checking.

Fast access to a text editor while on line: Mirror has a decent one built in; Crosstalk doesn't (although both programs will accept a DOS path to let you get to your own editor).

Security: You can use Crosstalk as a call-in system, but it lets you establish only one password for the entire system. Beyond that, you can pick one of four levels of file-manipulation clearance; but even at the most restrictive level, any caller who figures out the password and a one-character trigger command can move through your directories and view the contents of your files. You can configure Mirror to do the same thing if you like, but it can also ask for callers' names and *individual* passwords. Further, you can restrict or grant access to specific system commands on a caller-by-caller basis. Finally, you can have Mirror execute command scripts written for each caller. In short, although Mirror lacks a messaging system, you can turn it into a fairly complete upload/download bulletin board.

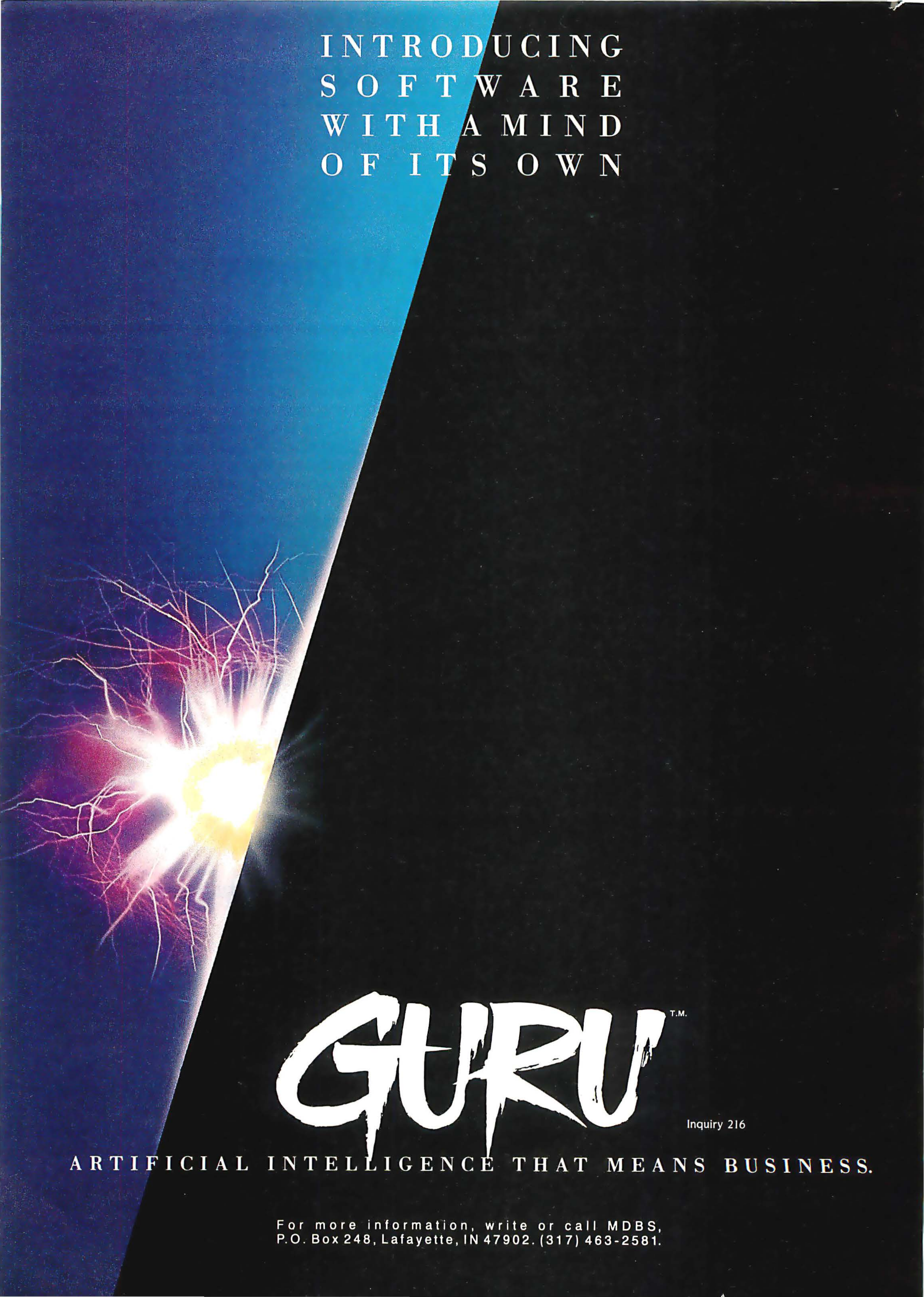
And now, here's the kicker: Mirror will perform protocol file transfers as a background operation. You initiate a transfer and press both shift keys, and Mirror becomes a concurrent memory-resident utility. The other night I downloaded a binary file (using XMODEM/CRC) to my C drive while *simultaneously* doing a DISKCOPY from A to B *and* spooling a file to my printer with the DOS Print utility. That's three memory-intensive disk-intensive operations at once. All went smoothly, with no noticeable degradation in performance. I then installed a new copy of Framework II in the C drive (talk about constant disk access!), did some maintenance, and typed a page of text. No problems.

According to Bruce Justham, who wrote the program with Don Waldo, the trick is simple. Mirror uses an internal 4K-byte buffer. At 1200 bps, it only has to flush the buffer to disk at half-minute intervals, so contention is infrequent.

Mirror is just small enough so that if you aren't running lots of pop-up programs, you can even load a big guy like Reflex or Framework while Mirror chugs along in the background. I've been experimenting with different software combinations, and I haven't experienced any major hassles. This

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Ezra Shapiro is BYTE's West Coast Bureau Chief. Contact him at BYTE/McGraw-Hill, 425 Battery St., San Francisco, CA 94111.


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means I might never again have to twiddle my thumbs while sending files. That fact alone makes Mirror worth the price.

Now it's only fair to point out that Crosstalk provides you with a much nicer manual in a nifty plastic slipcase; Mirror gives you a badly printed paperback book. And Mirror has some of the most garish screen displays (when it loads and exits) that I've ever seen. But I'm not complaining; I'll just grit my teeth and *use the product*.

FRAMEWORK REVISITED

When the original Framework was introduced, it took three of us (Rik Jadrnicek, John Markoff, and me) nine magazine pages to present a preview that barely scratched the surface of the program's operation (see "Framework," August 1984 BYTE, page 121). We were dazzled by the demonstrations we saw—windows appearing and disappearing like lightning, linked spreadsheets and databases recalculated at the touch of a key, massive programming capacity.

Yet, for the next year, every time I sat down and really tried to *use* the product, I'd find myself hesitantly tapping a few keys, scratching my head, and muttering, "How did they *do* that?" I'd decide it was too much bother, and I'd give up.

In some ways, I think Framework suffered because of the visionary nature of the product. In all its incarnations, it's been very much a toolbox for manipulating data. In Framework 1.0 and 1.1, the basic building blocks—word processor, spreadsheet, database, etc.—all seemed somewhat limited. The real power of the program lay in FRED, Framework's macro language. With FRED, you could do amazing things: link data items, replicate long sequences of keystrokes, manufacture complex computational formulas, incorporate external programs, and even develop menu-driven specialized applications.

Those earlier Frameworks lacked a lot of the amenities one normally expects in business software. For example, if you needed to change the output settings for a text document, you had to write a FRED program to do it, or you were stuck with the default values. If you wanted to learn to use the product well, you had to be willing to commit a lot of time to it, something that I, at least, looked at with a sense of doom.

Enter Framework II (Ashton-Tate, $695, 20101 Hamilton Ave., Torrance, CA 90502, (213) 329-8000; environment: MS-DOS)—older, wiser, and a lot more in tune with the real world. It's still the same product with the same philosophy, but it's now useful

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right out of the box rather than months later. Some of the improvements have been functional, some merely cosmetic, but they add up to a far less frustrating piece of software. Here are some high points.

Most formatting is now controlled by menus; you no longer have to learn FRED to put headers and footers on your printouts.

Framework II incorporates a decent spelling checker that you can use on spreadsheets or databases as well as text files.

Spreadsheets can now be as large as memory allows, up to 32,000 cells square. Framework II uses sparse matrix algorithms and swaps out to "extended memory," which can be EMS or Lotus/Intel/Microsoft boards, RAM disk, or even hard disk. With FRED's large collection of numeric functions, the spreadsheet portion of Framework II is arguably as good as any spreadsheet on the market.

The telecommunications interface has been completely redesigned and integrated into Framework II. In earlier versions, MITE, a stand-alone product from another company, was simply grafted onto Framework. Now, telecommunications sessions are treated like any other text; you can edit them or massage them with FRED programs. You could build an automated stock-tracking program that pulls quotes from an on-line service, feeds them into a spreadsheet or database, and hands you printed graphs. Note that this can be done as a background task, while you do other work.

Convenience functions have been added to most menus. You can perform word counts, insert soft hyphens and page breaks, execute mail merge or label printing, import and export files in foreign formats, and "goto" named locations directly rather than use the cursor. All this was possible before, but you had to load and run FRED programs; you couldn't just select menu items.

Now you can create macro commands by recording keystrokes as you enter them. Prior versions had no record/playback capability. And a library of macros loads automatically when you bring up the program; you no longer have to search for them on disk at the start of every session.

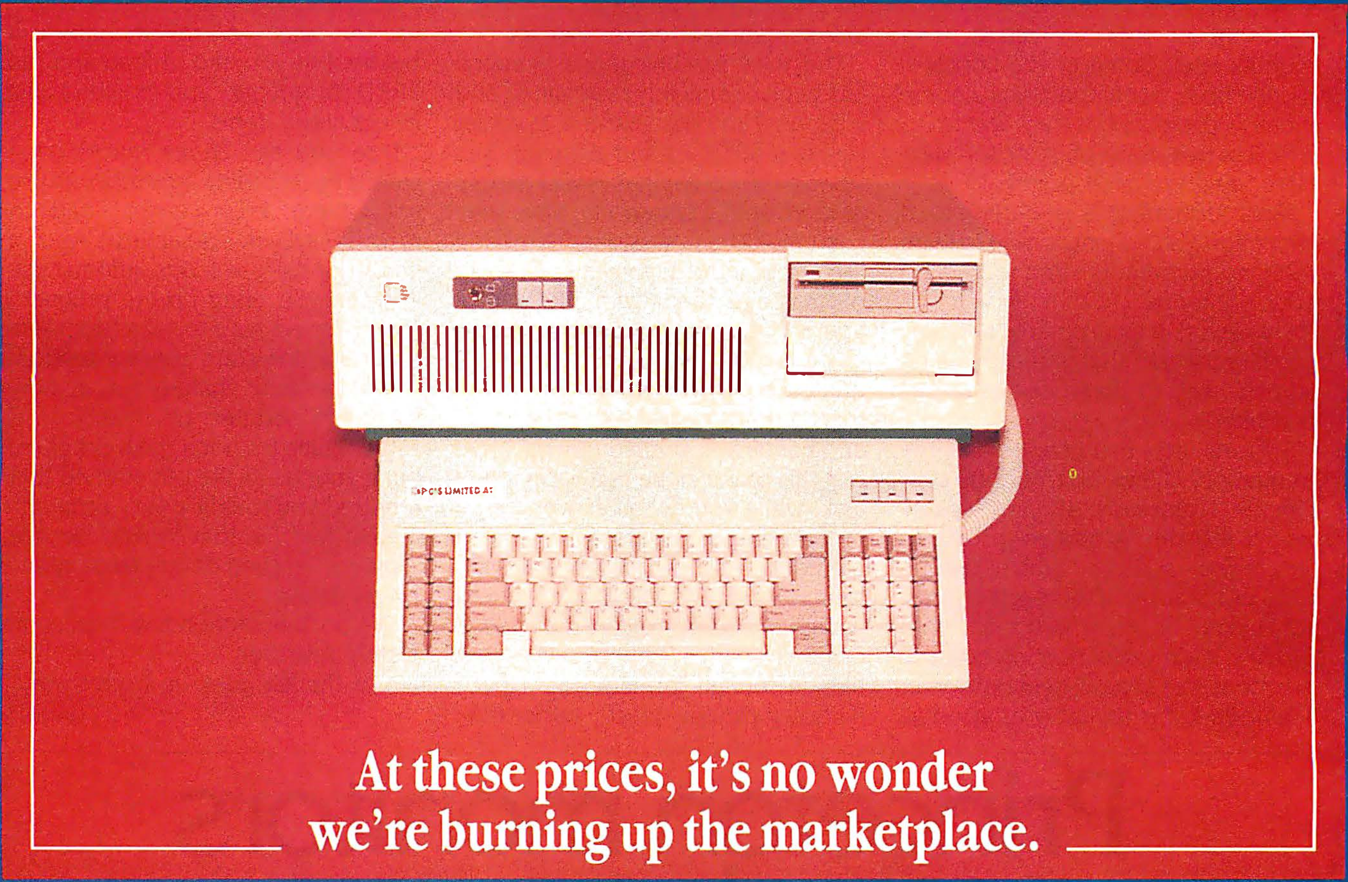
You can now change default configuration settings by means of a setup utility. It's not a great program, but it sure beats the old method that required you to edit a very programmerish text file that looked like the "equates" section of an assembly-language listing.

The documentation has been completely rewritten.

And the list goes on from there.

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What it adds up to is this: The component parts of Framework II now look and act a lot like stand-alone competitive products. The spreadsheet, database, word-processor, and communications sections are much less threatening. I've found that I have something familiar to hang on to; I'm no longer thrust unwillingly into the alien territory of frames and levels and macros and FRED. As a result, I've been able to produce useful work while slowly learning about all the nifty features that have always been part of Framework.

The program is still an integrator's toolbox; you design macro functions as you need them. I wrote my first FRED program a week after I began playing with Framework II, and it wasn't so bad after all. I figure it should take me a total of about two months of daily use before I can really tap the product's power.

That power makes Framework II a spectacular software-development environment. Because you've got both a solid programming language *and* full-blown applications, developing becomes a process of building bridges rather than starting from scratch. Framework has always been a nice front end for those other Ashton-Tate products, dBASE II and III. And as Framework can also digest files—with only sporadic belches—from Lotus 1-2-3 (including most formulas), IBM DCA, WordStar, MultiMate, and any program that generates either DIF or ASCII formats, the possibilities for integration extend far beyond the Framework desktop.

There is some irony here. Now that I'm feeling good about Framework II, I went back and looked at Framework 1.1 again, and it wasn't nearly as tough as I remembered. The convenience features of Framework II, coupled with good documentation and extensive help screens, have propelled me gently into the world of Framework. I'm now as excited as I was when I saw those first demonstrations.

Don't get me wrong; I'm not saying Framework II is for everyone. If you spend most of your time working with one kind of data, be it words or numbers, you might be better off sticking with your current software; Framework is necessarily more generalized. However, if you regularly move between two or more types of software or need tighter integration, Framework II is a good bet.

Just remember that Framework II is a big, powerful program that (like every other program in its category) has its idiosyncrasies. It pushes you toward macro programming, and it demands commitment.

But making that commitment is now quite a bit easier. ■

C·I·R·C·U·I·T C·E·L·L·A·R F·E·E·D·B·A·C·K

Conducted by Steve Ciarcia

LIS'NER 1000

Dear Steve,

I read with interest your November 1984 article, "The Lis'ner 1000." I have a custom application in mind based on the ideas behind the Lis'ner 1000, using a dedicated Z80A. Your design in figure 8 (pages 118–119) looks straightforward for almost any microprocessor. However, how would you connect the SP1000 pins $\overline{\text{CSI}}$, $\overline{\text{IRQ}}$, $\overline{\text{RESET}}$, and R/$\overline{\text{W}}$ to a Z80? Also, can you tell me what kind of software considerations I should keep in mind?

Finally, your 300-bps modem project using the TMS99532 was great ("Build the ECM-103, an Originate/Answer Modem," March 1983). I noticed that the Micromint offers a direct-connect transformer for it, and I would like to know how it connects to the modem board and the telephone line.

ANDY PICKETT
Indianapolis, IN

Interfacing the SP1000 to the Z80 microprocessor is not difficult, if you have sufficient experience. Much of the interfacing is concerned with how the SP1000 will be addressed (i.e., which memory locations will be allocated for the chip). You must decide whether or not the SP1000 will be memory-mapped or I/O-mapped. If you don't understand these terms, refer to any book about microprocessor-circuit design.

You will have to determine how to connect the $\overline{\text{CSI}}$ pin (pin 6), depending on the configuration you choose. The $\overline{\text{IRQ}}$ pin (pin 28) can be connected to pin 16 of the Z80. As for the R/$\overline{\text{W}}$ pin (pin 5), two separate signals for these operations are on the Z80. One way is to connect just the Write pin (pin 22) of the Z80 to pin 5 of the SP1000. This means that the SP1000 will output data on the data bus whenever Z80 is not writing and Chip Select is active. When a write operation occurs, data is placed on the bus by the Z80 and is written into the SP1000 when Chip Select is active and the Write pin of the SP1000 is active. The $\overline{\text{RESET}}$ pin connection depends on your application. It can be hooked up to a system reset of some sort or a power-on reset (or a combination of both). Another alternative would be to let the microprocessor access a unique address that is set aside as a reset command to the SP1000. In this case, when the microprocessor accesses that memory location, the SP1000 would be reset. Again, this depends on your application and exactly how you want the system to work.

While the Lis'ner 1000 was designed for the Apple II and Commodore 64, there is no reason why you can't design a working system around the Z80. If this is going to be a dedicated microprocessor, you will probably be writing the entire software package in assembly language. This is not a difficult task. Follow the flowchart in figure 11 on page 122 of the November 1984 issue for general guidelines. The following books about the Z80 and designing a working computer around it will help you: Build Your Own Z-80 Computer *by me (BYTE Books, 1980) and* The Z-80 Microcomputer Handbook *by William Barden Jr. (Howard W. Sams, 1978).*

Regarding your question about the direct-connect transformer for the ECM-103, the information is included when you buy the transformer. The ECM-103 is not FCC-approved for direct connection to the telephone lines, which means that you should also use an approved and authorized interface between the modem and the telephone lines. —Steve

SB180 ADAPTATION

Dear Steve,

I read with great interest your SB180 article beginning in the September 1985 BYTE. Bravo!

I have been accumulating materials and ideas for the last year with the prospect in mind of building a Z80-based S-100 system. I was fully reconciled to living with the shortcomings of CP/M and looking forward to a system running at 6 MHz. You can imagine how happy I felt when I read your comparative description of the Z-System and CP/M 2.2.

You mentioned that the SB180 was the 29-chip equivalent of a large S-100 system. Is there any way for me to get some help in adapting the SB180 to my S-100 project? I have the technical capability to produce my own printed-circuit layout for the board. However, if there is hardware already available, I'd sure like to know about it.

WILLIAM BROOKS
Vista, CA

Thank you for your kind words. Far be it from me to discourage you from building an S-100 64180-based system, but I really don't know of anyone doing that at this time. One of my engineer friends claims to have seen a small ad for such a beast but can't remember where. If it is speed you are after, get in touch with a company known as Earth Computers (POB 8067, Fountain Valley, CA 97278, (714) 964-5784). This company has an 8-MHz Z80H S-100 board that is about twice as fast as an IBM PC and comes close to AT performance (at least on the BYTE Sieve of Eratosthenes benchmark). Echelon Inc. (101 First St., #427, Los Altos, CA 94022, (415) 948-3820) has both a manual-install and an automatic-install version of ZCPR3 for CP/M 2.2. Of course, you won't have the memory address space of the 64180, but there are few commercial programs available that make use of the 64180 anyway.

I hope that you have good luck with your project.—Steve ■

Due to an overwhelming response and increased production rate for the SB180, as described in the September and October 1985 Circuit Cellars, the assembled and tested SB180-1-20 "BYTE readers' special" price of $499 has been extended indefinitely by Micromint.

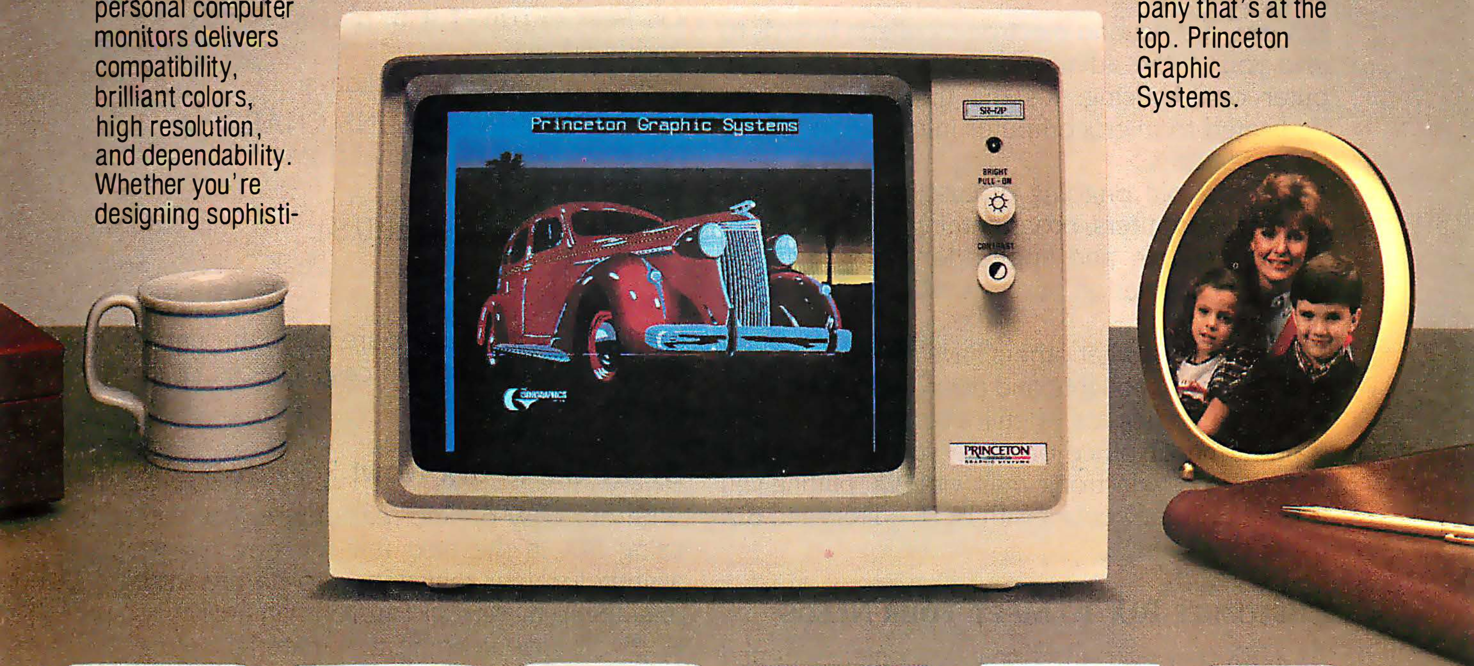
Over the years I have presented many different projects in BYTE. I know many of you have built them and are making use of them in many ways.

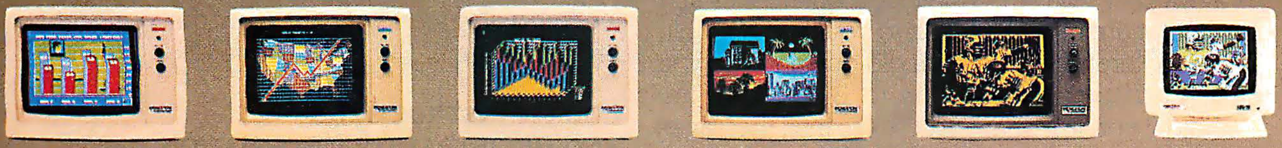
I am interested in hearing from any of you telling me what you've done with these projects or how you may have been influenced by the basic ideas. Write me at Circuit Cellar Feedback, POB 582, Glastonbury, CT 06033, and fill me in on your applications. All letters and photographs become the property of Steve Ciarcia and cannot be returned.

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Having your credit card handy (VISA/MasterCard) before you log on will speed you through BIX registration. *You will not be billed for the time you spend on line registering for* BIX. *If at any time during the on-line process you decide not to register for* BIX, *just hang up.*

HOW TO LOG ON TO BIX:

Step 1: Set your computer's telecommunications program for full duplex using 8-bit words, no parity,

and 1 stop bit, or 7-bit words, even parity, and 1 stop bit. You may call at either 300 or 1200 baud.

Step 2: To reach BIX via Tymnet.*

* *BIX is accessible from anywhere in the country through local Tymnet numbers. If you don't know the Tymnet numbers for your area, contact the BIX Customer Service Line (see below). At other times, numbers can be obtained by calling Tymnet at 800-336-0149.*

- Call your local Tymnet number and log on.
- Depending on your baud rate, Tymnet will respond with "garble" or request a terminal identifier. Enter the letter "a". (Ignore quotation marks in this and succeeding entries.)
- Tymnet will ask you to log on. Enter "byteneti" and a carriage return (CR).
- Tymnet will ask you for a password. Enter "mgh" and (CR). You will then be at the door to the BIX computer.

Step 3: (If there is no prompt requesting a login at this point, hit a (CR) which should produce it.) When you see a phrase ending in "login:", enter "bix". (Echoing of this response is normal.)

You should now see the BIX logo scroll onto the screen and a prompt asking you to enter your name. Since this will be your first time on the system, enter "new" and a carriage return. This will take you to a special section where you enter the information we need to register you as a BIX user. Follow the on-line prompts and supply the information requested. BIX lets you re-enter data if you make a mistake.

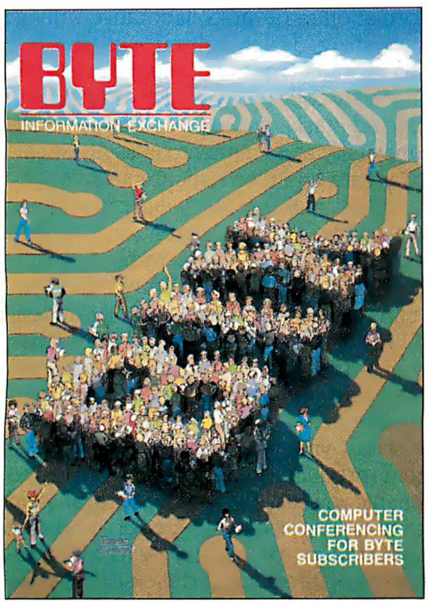
When you've completed your registration, BIX will automatically take you to a special "Learn" conference where you'll get a quick tutorial on how to use the system. (Typing "help" or "?" at any prompt while you are on BIX will give you an immediate review of available commands.)

ACCESSING BIX FROM FOREIGN COUNTRIES

To reach BIX from other countries, you need an account with your local Postal Telephone & Telegraph (PTT) company. From your PTT, enter 310600157878. Then follow instructions starting at Step 3. A list of PTT addresses and contacts for most foreign countries is available by calling or writing BIX.

CUSTOMER SERVICE

If you follow these instructions but still are unable to log on to BIX, call the BIX Customer Service Line for assistance at 800-227-2983, 8:30 a.m.–11 p.m. eastern time weekdays. In New Hampshire and outside the U.S., call (603) 924-7681.



We'll Send You a BIX User's Manual and Subscriber Agreement As Soon As We've Processed Your Registration

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70 MAIN STREET
PETERBOROUGH, NH 03458
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(continued from page 32)

Systems Inc. of Ann Arbor, Michigan; (2) CONFER II resides on mainframe computers at the University of Michigan, the University of Alberta, Canada, and at Hewlett-Packard, as well as Wayne State University in Detroit, and it is accessible from anywhere in the U.S. through public data networks such as Telenet; (3) the Army's think-tank uses of CONFER II, although initiated through the Delta Task Force, are now in the hands of the Army Forum, who have expanded productivity throughout the Army; and (4) although there are similarities in "information mapping" to the CONFER II structure, it is actually the CONFER II documentation that is based on the principles of "information mapping."

BYTE Associate Editor Donna Osgood was really on target in her comments in the theme introduction (page 166). Computer conferencing can provide the means for letting creativity and dialogue, the cornerstones of an effective organization, take place; it can help participants work together at their convenience but within the constraints of imposed deadlines and geographic separation. Through computer conferencing, the possibilities are practically limitless for the sharing of ideas and the exchange of information to speed decision making and improve overall productivity.

ROBERT PARNES, PRESIDENT
Advertel Communication Systems Inc.
Ann Arbor, MI

Brock Meeks's December article includes mention of GENIE, an integrated system marketed by Data Dynamics Inc. Some information was omitted from the article that may be of interest to readers.

Data Dynamics is an information-management software company. Its product, GENIE, is a comprehensive, unified, expandable, and fully integrated information system that meets key needs of managers and professionals. GENIE has been installed at over 50 sites worldwide.

Customers use GENIE to expedite communications among managers and professionals by keeping track of schedules; increasing meeting effectiveness; automatically documenting meetings; helping produce memos or documents more efficiently than secretaries can; and facilitating a variety of professional tasks including information retrieval, collaborative writing, publishing, design walk-throughs, project management, decision support, networking with colleagues, and managing dispersed task groups. California State University at Sacramento is using GENIE to create an "Electronic Campus."

GENIE has the following capabilities: electronic mail, conferencing, bulletin boards, screen editing, formatting and publishing, filing and retrieval, calendar management, and system administration. GENIE is easy to learn and use since it has a uniform command set, a training level with automatic instruction, and simplified on-line help.

Data Dynamics' Decision Support System product operates with GENIE to enable discussion, final approval, and automatic documentation of modeling assumptions or budget items via computer conferencing and then to expedite final distribution of resulting models or spreadsheets and associated graphics via electronic mail.

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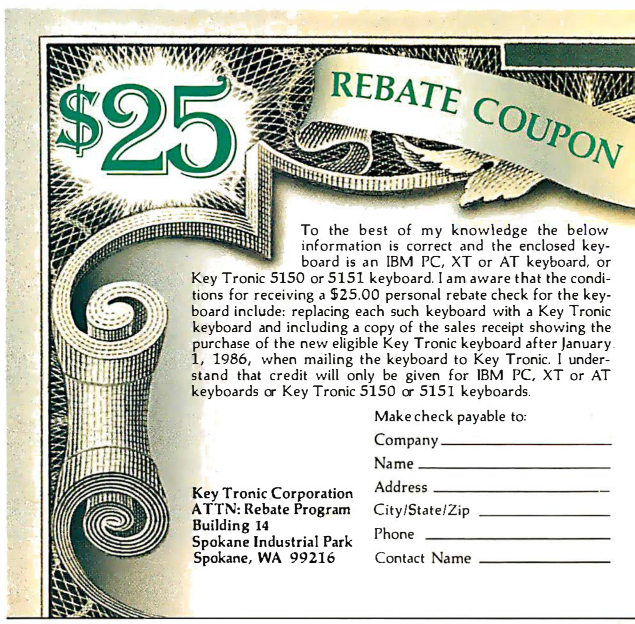
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GENIE's publishing capability can be used to lay out and print near-typeset-quality camera-ready copy of completed spreadsheets, reports, or papers on a variety of laser printers.

STEPHEN A. HEITMANN, PRESIDENT
Data Dynamics Inc.
Portland, OR

For more information on the availability of the conferencing systems covered in Brock N. Meeks's article, see this month's Fixes and Updates on page 33.

For your readers' information, my company's CONEXUS and MIST+ software package has been acknowledged as the first conferencing package for the IBM PC family. Since its introduction in May of 1984, our software has been installed in over five hundred Fortune 1000, university, association, and small-business locations. It has been proved to be an easy-to-manage product for private electronic mail, unlimited topic-specific computer conferencing, and keyword retrieval of bulletin-board items.

CONEXUS was written by Peter and Judy Johnson-Lenz, who were on the design team that resulted in the Electronic Information Exchange System (EIES). They authored TOPICS, an EIES application that later was transformed into PARTI, and they authored MIST in 1982 and MIST+ in 1983. MIST has been acclaimed as the first integrated communication application language for personal computers.

CONEXUS, although a complete application, was written using MIST+, which means that more experienced users can add their own features as well as take advantage of MIST+'s integrated text-oriented database-management system. We know of no other package that has the track record, power, tailorability, and sophistication of CONEXUS and MIST+.

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RATIONAL PASCAL

I thought your readers would be interested in learning about our work on the language that will be the successor to Modula-2. Your readership is so diverse and wide-ranging, particularly within the computer-languages community, that I would deem it a privilege to make my first formal announcement of this effort in the pages of your publication. If I may, I would also like to discuss briefly the philosophy

behind our project.

A few years ago, efforts were made to salvage FORTRAN by implementing "Rational FORTRAN," or RATFOR. We are borrowing a leaf from the same philosophical book, so to speak, by implementing "Rational Pascal," which we are puckishly calling "Rascal." We believe that Rascal may fairly lay claim to being the ultimate computer programming language by virtue of its extreme elegance, power, and simplicity. Let me cite a few examples.

In Rascal, recursion is mandatory. Every Rascal routine, once invoked, must immediately do one of two things: It must either *call* itself, or it must call some other routine that, in turn, immediately calls itself. Any additional code (e.g., that which tests to see whether it is appropriate, or even permissible, to execute a return) must follow this initial recursive call. Thus, the language enforces the elegant simplicity of a unary tree.

Rascal recognizes only one data type: the record. Every Rascal variable and constant must be defined as a record, even if that record has only one member. This requirement yields the inestimable benefit of completely eliminating machine dependencies. It is of absolutely no consequence whether a machine integer consists of 16, 32, or 78 bits, because the very idea of an "integer" is alien to Rascal. Instead, all data objects must be records, and their elements, naturally enough, must also be records. The most primitive record, from which all others must be constructed, is a single Boolean value.

Because Rascal has no machine dependencies whatsoever (and because—of course—it is written in itself), we have decided that a preliminary release of the source code should be made available to *any* individual willing to serve as a beta-test site. This release is scheduled for April 1, 1986. Interested persons are asked to contact me directly, at the address that follows.

GERHARD WERTHER VON WIRTH
Technisches Irrenhaus
Zürich, Switzerland

PRAISE FOR AVSIM

I am writing to report on a product that will interest those of your readers who teach microcomputer architecture or assembly-language programming at a college or university level. At Ryerson Polytechnical Institute we have been using Avocet System's AVSIM family of simulator/debuggers for the past year and a half for our instrumentation course and thesis

(continued)

projects with dramatic improvements in both quality and speed of learning.

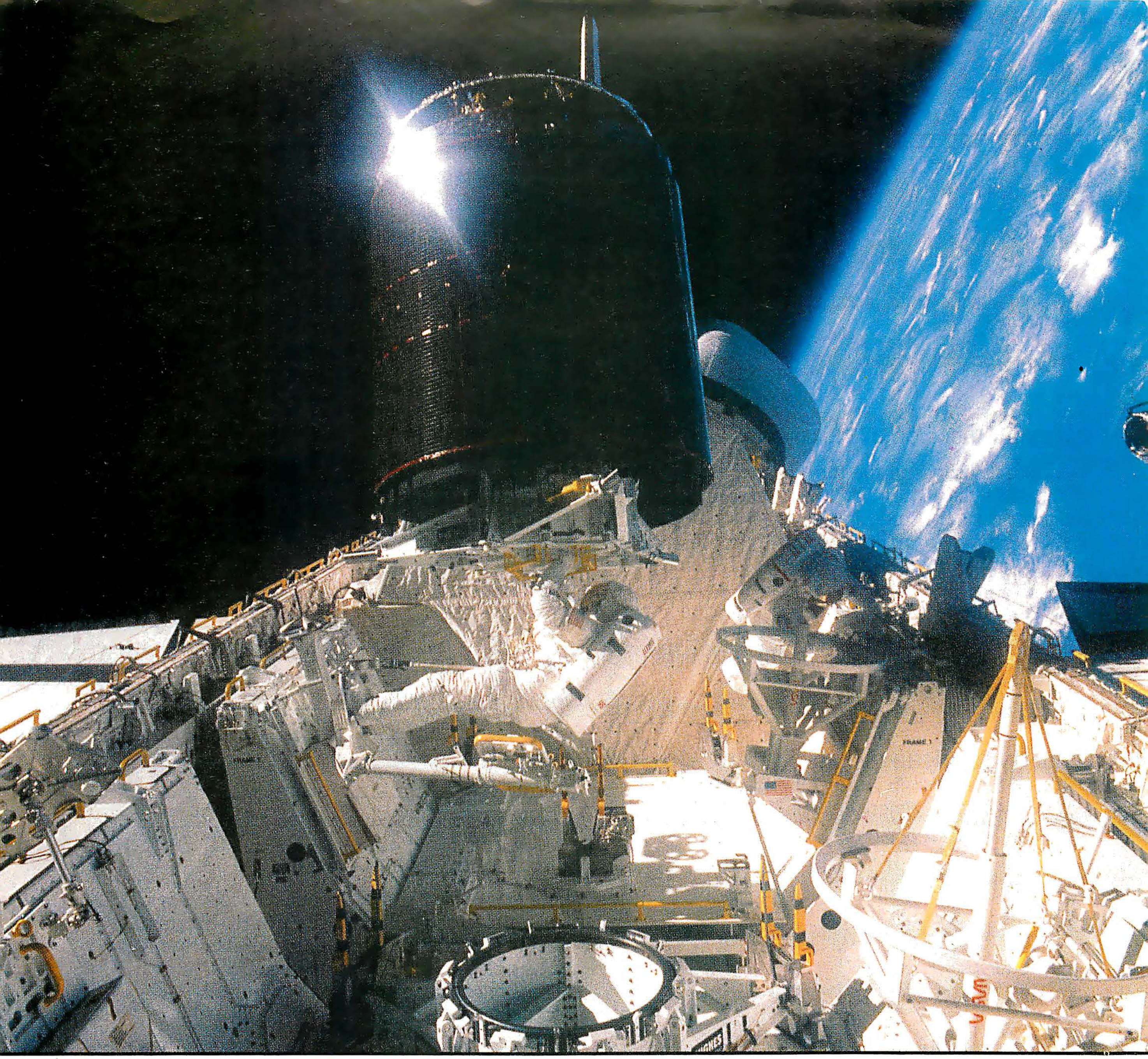
To describe AVSIM briefly—it is an interactive, screen-oriented, symbolic simulator for microprocessors that is hosted by any MS-DOS computer. After cross-assembling a program, the student loads the object file and symbol table into the memory space of the simulated target machine and runs the program on the visual CPU, watching what happens to registers, flags, memory areas, etc., as each op code is executed. Besides the usual single-step, run, and breakpoint features that every debugger has, AVSIM also has an invaluable Undo key that lets the student step the CPU backward through the execution history, even backing into interrupt routines. By alternately single-stepping and using Undo on an instruction, the student can see exactly what effect the instruction has on the system. The environment presented by AVSIM is not only friendly but also robust: *It hasn't been crashed by any student's program yet!*

I spend less than five minutes teaching the basics of AVSIM: how to load object code, reset the target CPU, and use the function keys that control the simulation. Changing memory, register, or I/O pin values is intuitive: Position the cursor over the current value and edit it—like a text editor. There are function keys defined to increment, decrement, or toggle the bit, nybble, or byte under the cursor. On-screen editing is possible even while the student's program is running, so that I/O pins or interrupts can be toggled interactively to exercise the program.

My experience with AVSIM has been very gratifying. With 120 thesis projects to coordinate, I must ensure that we can provide development tools for the various CPUs used by students. Now we support seven different CPUs on the same hardware. There are no costly emulators to break down or become out of date every few years. Students can do their debugging after hours, using one of the microcomputers in the college library (or their own, if they have one) and fix the vast majority of bugs by themselves.

Based on this success, we are purchasing 22 IBM PCs for our third-year lab to integrate AVSIM into our existing MC6800/MC6809 software/hardware course. By using AVSIM to teach assembly-language programming before providing hands-on experience with the 6800 hardware, I anticipate similar improvements in student performance and lab efficiency.

MIKE KASSAM
Toronto, Ontario, Canada ■



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Ordering Disks of BYTE Listings

Source-code listings in the form of text files of programs that accompany BYTE articles are now available from BYTE on disk. To order a disk of these listings for noncommercial purposes, indicate the issue (the first available is December 1985) and the kind of disk on the form below. Enclose a check or money order in the correct amount made out to BYTE Listings. All prices include postage. Send requests to BYTE Listings, 70 Main St., Peterborough, NH 03458.

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- ☐ TRS-80 Model III
- ☐ TRS-80 Model 4
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Bulletin Boards in Canada

Listed below are some computer bulletin boards that carry program listings from BYTE. Programs are for noncommercial use in connection with BYTE articles only. Some BBSs may charge an annual maintenance fee, and you must pay your own telephone charges.

Western Canadian Distribution Center (101 11112 101st St., Edmonton, Alberta T5G 2A2) will be supplying listings to its member bulletin-board systems.

Edmonton, Alberta, (403) 454-6093

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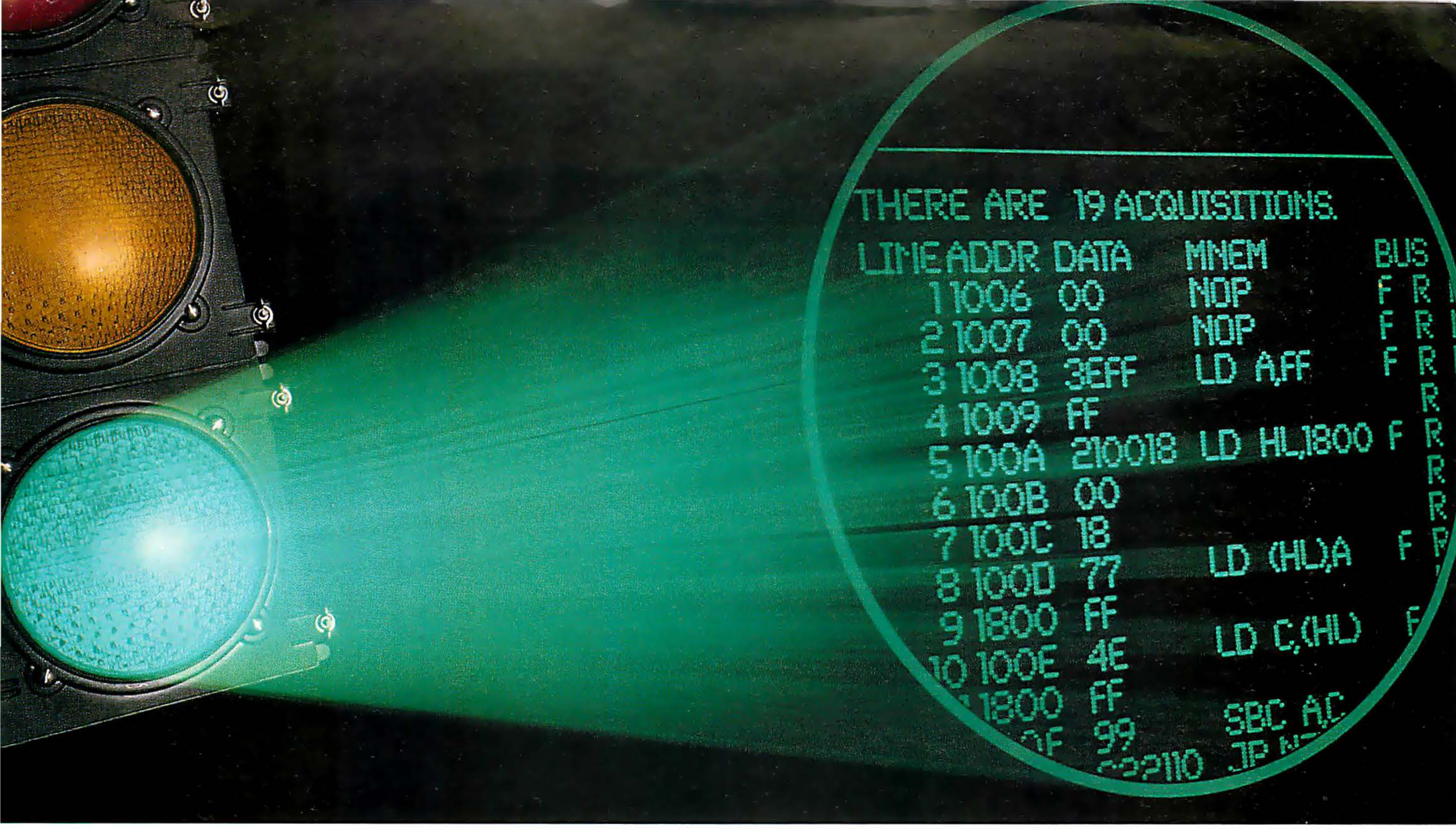
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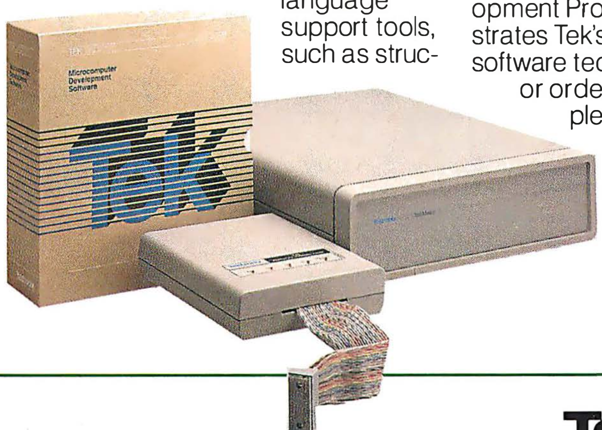
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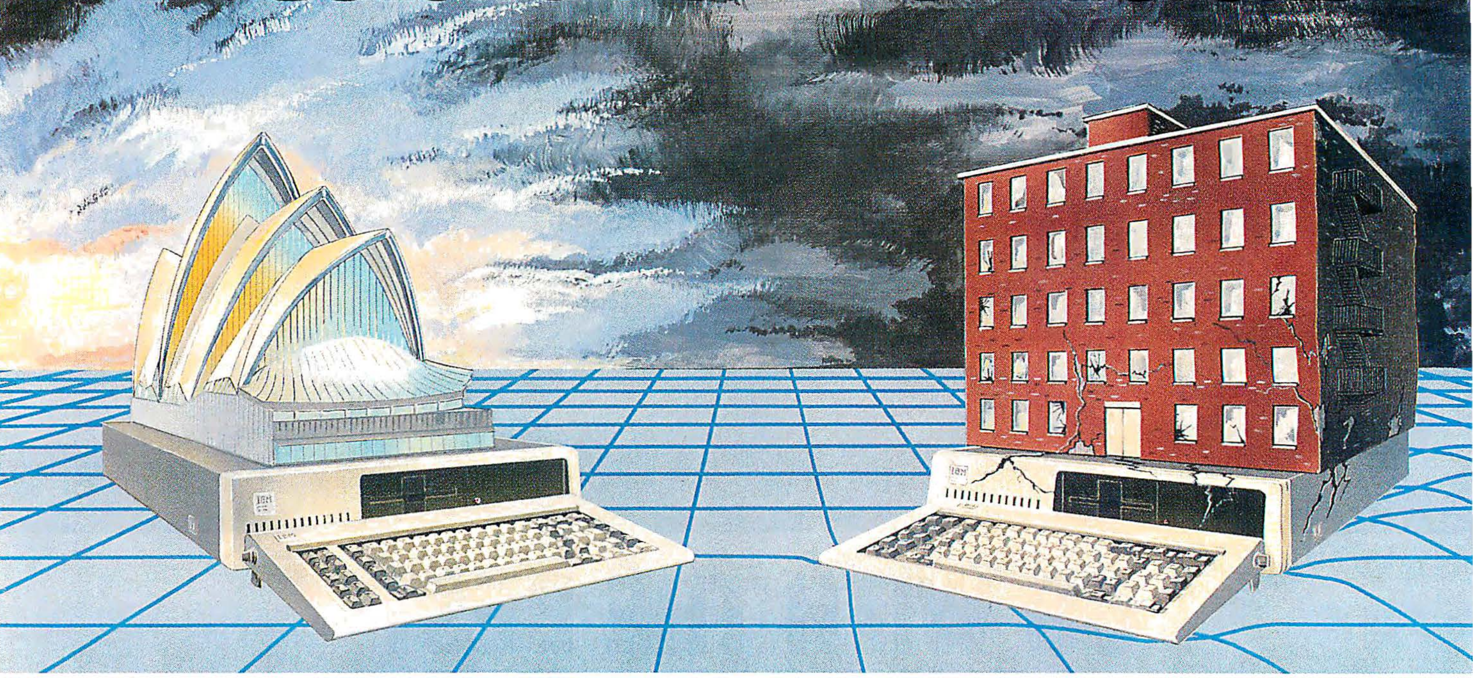
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Inquiry 341

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Inquiry 282

AMIGA

The April Amiga conference highlights include an in-depth look at specifications for Amiga-compatible monitors, a number of ways to create C and CLI work disks, and more information about upgrading your Amiga to a 68020 CPU. Charlie Heath compares smart refresh versus simple refresh and provokes discussion of various communications protocols including XMODEM files for BIX. This Best of BIX section concludes with instructions for adapting 5¼-inch floppy-disk drives, Bernoulli disks, and different ways of preserving the Preferences from your Amiga Workbench.

MORE ABOUT MONITORS

Editor's note: The following messages should put an end to the controversial rumors that Amigas can use only *Amiga monitors. This is absolutely untrue.*

amiga/tech.talk #258, from atm [Andrew McLaughlin]

Screen Resolution
I'm a little confused (can anybody help me?). I've been looking for an alternate monitor for the Amiga and I haven't seen any that are exactly 640 by 400 pixels. The closest I've seen has been 720 by 480 pixels. Questions are: Can I use this monitor? If I do use this monitor, will I end up with an extra 80 pixels on the side and bottom of the screen image? Or will the 640 by 400 image be averaged into the 720 by 480 screen?

When the manufacturer says "720 by 480 pixels" I'm assuming that the shadow mask is a matrix of 720 by 480 holes, right? Should I worry about the 640 by 400 interlace from the Amiga? (Do I need a special monitor or will any RGB monitor do the interlace stuff?)

I understand that using RGB analog I can get all 4096 colors but with RGB digital only a select few colors are available. Is this true? Why offer two different RGB modes when the analog mode is obviously more desirable? Or is there an unmentioned trade-off?

Those are all that I can remember (yeah, sure). Hopefully, I'll be able to get the story straight. Thanks in advance for any help.

amiga/tech.talk #259, from jsan [Jez San, Argonaut Software]:
a comment to 258

Go buy your 720 by 480 monitor. The extra pixels are probably *overscan*, which is quite normal; it's the border around the displayable portion of your Amiga screen. RGB digital output is for IBM PC-compatible monitors, but naturally, RGB analogue (analog for yanks!) is best if you are given the choice!

amiga/tech.talk #260, from atm:
a comment to 259

Does that mean that the Amiga monitor is 720 by 480?

amiga/tech.talk #261, from jdow [Joanne Dow]:
a comment to 260

Make sure the monitor uses 15742-and-change hertz for the horizontal scan and 59.94 or so hertz frame rate interlaced. Otherwise it might not run. The KV1311CR and the XBR series will give you full Amiga resolution. The quoted 640 by 200 lines is for noninterlaced sweep. The vertical resolution in the Amiga interlaced mode is easily sufficient to do anything the Amiga needs.

amiga/tech.talk #263, from atm:
a comment to 261

"Make sure the monitor is '15742-and-change' hertz for the horizontal." I don't understand what you're trying to say here. Please explain.

amiga/tech.talk #264, from hvanderbilt [Henry Vanderbilt]:
a comment to 263

That's a 15-kilohertz horizontal sweep rate that you want in your monitor, give or take a bit. That is pretty much the standard for color TV and composite monitors and for RGB monitors that aren't designed to work with some specific nonstandard format. With 60 fields a second and 262 lines a field (only 200 on screen), you get 15,000+ lines displayed per second. The horizontal sweep circuits in most monitors will sync up to anything reasonably close to the right rate, so the exact number isn't vital.

amiga/tech.talk #266, from jdow:
a comment to 264

I waxed a bit technical to say you want a monitor designed to work with NTSC standard sweep rates. Many higher-definition monitors are designed for higher sweep rates on both horizontal and vertical. These will not work very well with an Amiga designed for NTSC sweep rates that are nominally 15750 Hz and 60 Hz, respectively. Actually, they are about 15734.27 Hz and 59.94006 Hz. This latter defines why that noise bar from the leaky line transformer or insulator outside your bedroom window slowly moves down your TV screen. Or is it up (haven't seen one since cable days)?

amiga/tech.talk #267, from duck [Dale Luck, Commodore-Amiga]

Monitor Resolution and Your Amiga
The 640/720 horizontal resolution is actually nearly the same. The 720 monitor puts those dots on a longer line; therefore, the video bandwidth is actually the same.

For those of you rolling your own graphics and not using Intuition, the Amiga is capable of outputting a display of around 700 by 220 pixels. The amount of information you actually see is dependent upon your monitor. The graphics library supports just about any odd/large viewport size as long as it can fit it in the bandwidth of the memory without running into the horizontal sync. Higher resolutions may kill off some of your sprites, though. Just thought you might like to know.

XLISP 1.6 FOR AMIGA

amiga/main #984, from jdow:
a comment to 983

XLISP 1.6 for Amiga—Being a software collector I'd be interested so I can pass data on to interested friends. We have a couple LISPians at work who would probably find some interest in the PC version as well.

[*Editor's note: XLISP 1.6 is now available on BIX in the Amiga section of the Listings conference.*]

CREATING C WORK DISKS

amiga/main #987, from dbetz [David Betz]

Minimal Disk
Can anyone suggest what a minimal set of files for a bootable disk would be? I'd like to free up as much space as possible on my working "Workbench" disk, but I can't find a list of "required" files anywhere. I'm using the Lattice C compiler and the CLI for development, so I don't really need to run anything from the Workbench except for the CLI (for that matter, is it possible to get the machine to come up in the CLI in the first place?).

(continued)

amiga/main #989, from jsan:
a comment to 987

To make a CLI disk, edit your start-up file on the Workbench, e.g., Edit s/startup-sequence.

Remove the offending line that says "LoadWb." That's the command that tells Workbench to execute. Leaving this line out of your start-up sequence will make you boot up into CLI! Have fun!

amiga/main #990, from greggw [Gregg Williams, Senior Technical Editor, BYTE]:
a comment to 987

I, too, would like to see the definition of a minimal C disk. As for bypassing the Workbench, you can take out those lines (I remember taking out two lines) from s/startup-sequence or hit Control-D as soon as you see the first text message. Using this method, you have a disk that's either a Workbench or a CLI disk!

amiga/main #992, from sdb [Scott Ballantyne]:
a comment to 987

Just remove the LoadWb and the EndCLI > nil: lines from the s/startup-sequence file. Seems to me you can get along with the C directory (some commands can be deleted maybe—edit, for example, if you never use it). You will need the libs, you will need the devs, but you will probably only need one printer driver. Preferences might be worth keeping. That's about it. Anything you leave on the boot disk can be removed from the disk with the "includes" on it. Leaves *lots* of room for source.

amiga/main #1000, from cscheppner [Carolyn Scheppner, Commodore Business Machines]:
a comment to 990

Some suggestions for minimal C disk:

1. Back up Workbench and boot with the backup.
2. Make sure your Preferences are set the way you want them.
3. Edit the file s/startup-sequence: Remove the LoadWb and the End-CLI lines; add a line: Stack 10000
4. Delete all .info files.
5. Delete all demos, Notepad, Clocktool.
6. Delete system directory and contents (Workbench stuff).
7. If you don't plan to use disk fonts, delete all of them.
8. In devs/printers/. . . delete all printers you don't need.
9. In the c directory, you can delete anything you'll never use (for example, edit, LoadWb). Remember, many commands such as "if," "lab," and "abort" are used in script files for compiling. Don't delete commands used in your make script.
10. Delete Preferences. If you ever need to change them, you can do it on another disk; then copy the devs/system-configuration/. . . to this disk.
11. *Note:* Do *not* delete anything in the "l" directory! These items are needed for system management.
12. Copy contents of the C "c" directory to this disk's c directory.
13. Copy contents of the C "s" directory to this disk's s directory.
14. Make a "lib" directory on this disk and copy contents of C "lib" directory to it.

Now you should have everything you need, except for the includes, on a bootable C system disk. Make a backup of the original C disk, delete the c, s, lib, and example directories and contents, and add your own directories for your source. Change your make script so it looks for the includes in df1:include.

(continued)

DO YOUR OWN 68020 UPGRADE

amiga/tech.talk #270, from jdow

68020 Conversion Data
Visit your nearest Jan 9, 1986, copy of *EDN* either in your mailbox or local technical library. In the Design Ideas section, pages 216, 218, and 219 have a schematic for a plug-in board to install a 68020 into your 68000 sockets. The Design Idea is titled "68020 Adapter Upgrades 68000 Systems." It has ⅓ page of description and two pages of schematic.

However, gang, if you harken back to the June 20, 1985, copy of *EDN* you will find an article titled "Hardware and Software Strategies for the 68020." It hides on pages 89–98 (minus a page or two of ads). On page 90 there is a schematic showing how a 68020 and a couple of logic gates can be hooked up to provide a plug-in for the 68000. This second one is a whale of a lot simpler and I don't know how well it will work. In fact I do not know (yet) whether either of them will work.

Anyway, that's where you find the data for a do-it-yourself 68020 conversion for your Amigas. Good luck, and if you try it, let us all know how it works.

SIMPLE REFRESH VERSUS SMART REFRESH

amiga/main #1419, from cheath [Charlie Heath, MicroSmiths]

Simple Refresh versus Smart Refresh—A Request for Opinions
The purpose of this message is to ask about a trade-off of display memory versus a bit of display roughness. This is particularly relevant for applications that are intended to run in the Workbench screen (be they invoked from CLI or icons) and that are useful in multitasking. Thus, in particular, this is relevant to text editors and communications programs. Here are the two options:

1. If a program uses SMART_REFRESH windows, Intuition will maintain the display, and when windows are moved around or depth-arranged, SMART_REF windows will be updated very quickly, with a minimal ammount of display hashing, etc. *But* this is at a significant cost in display memory, to the tune of 32K bytes of display RAM for each full-screen SMART_REFRESH window.
2. If a program uses SIMPLE_REFRESH windows, Intuition does not save the various windows, and when windows are moved or depth-arranged, the program must redraw the windows; the result is that the display is not very pretty during these transitions. A good text display will need about a half second to render a full screen. *But* this buys a *big* savings in display memory, and as a result, multitasking is much more practical.

My guess is that most people will perceive the programs that use SMART_REFRESH as being superior because the display is cleaner, and that such programs will be more commercially successful as a result, even though they are less useful. Anybody care to defend either choice? Thanks.

amiga/main #1420, from michaelmounier [Michael Mounier]:
a comment to 1419

The only program I know of that uses simple refresh is Amiga BASIC, and it is painfully slow when it comes to refreshing windows. I would rather they just used a little more memory and smart refresh rather than have to sit there waiting for the window to refresh.

amiga/main #1422, from duck:
a comment to 1419

In a smart refresh window, the extra memory is only needed if the bits are obscured by another window. The significant cost in display

(continued)

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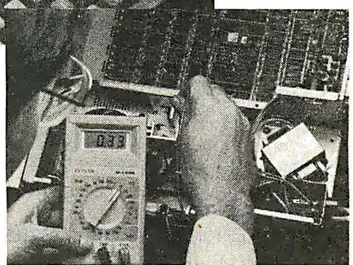
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memory you mention is less than 10 percent of the total 512K bytes of memory. Maybe a different adjective would be more appropriate.

For "text-only" displays, the difference is probably very close to 32K in a full NTSC screen. (Note PAL has an extra 56 lines per screen.) Since text can be efficiently stored in a text array, or just strings of text, the cost to save the text at most is 1K.

For graphics displays, you must also now build a "display list" that must be redrawn each time the user pops it up front. The display list itself can become rather large in size. I think the answer depends on your application and what you think the relative mix of user window ops (wops?) will be.

The SMART_REFRESH does not buy you much if the user is doing a lot of sizing. The bits are not saved when he sizes down. When he subsequently sizes up you must redraw to restore those bits. If he is going to do pops and pushes primarily, then SMART may be smart. Maybe a little prototyping and experimenting is called for. You can design your application using SMART_REFRESH first and then add the refresh stuff later if you need the extra memory.

Note that memory usage is global. Even though you write your program to be a good citizen and use minute quantities of memory and sacrifice a little in display speed does not mean other applications will follow suit. Maybe applications could be written to operate in both manners and let the user customize them. If he has lots of memory he can set all the FAT bits in his applications. If he has very little memory or is running thousands of applications at once he turns off the FAT bits.

amiga/main #1423, from duck:
a comment to 1420

The drawers in your Workbench are SIMPLE_REFRESH. The CLI is SMART_REFRESH.

PROTOCOL PROBLEMS

amiga/main #985, from cheath

Problem with XMODEM and Amiga

I uploaded a file to the Listings conference, a demo version of our text editor TxEd, and it has now been posted. Got a note from jdow, saying she couldn't get it to run. So I downloaded it, and indeed there is a problem. And the problem is that the Amiga binary file loader can't deal with garbage at the end of an executable file. Well, any good XMODEM hacker knows that XMODEM sends blocks of 128 bytes. *So, you can't use XMODEM to transfer executable files* on Amiga.

For the adventurous among you, I managed to get TxEd working after downloading it by truncating it (using, of course, TxEd) and making sure the size is exactly correct. The *correct* size of TxEd is 19,896 bytes. The version of TxEd that you will get by downloading is 20,096 bytes. So, figure out a way to chop off those extra 200 bytes, and you're in business.

P.S.: I'm posting a C file in the amiga/tech conference that will allow you to get TxEd running.

amiga/main #1284, from langeveld [Willem Langeveld]:
a comment to 1270

The Amiga BASIC program to cut the last 200 bytes off TxEd after XMODEMing it down is

```
OPEN "TXED" FOR INPUT AS 1
a$ = INPUT$(LOF(1) - 200,1)
CLOSE 1
OPEN "TXED2" FOR OUTPUT AS 1
PRINT# 1,a$
CLOSE 1
END
```

(continued)

Uplifting news.

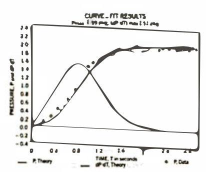
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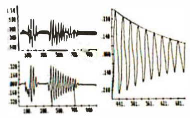
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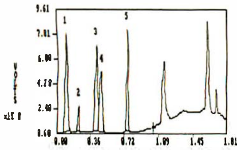
Take a look at these:



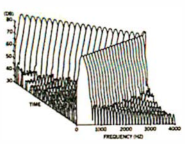
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. . .for those of us who haven't decided what C to buy.

P.S.: Now where are those executables in the Listings area with a little note saying how long they should be?

amiga/main #1009, from crunch [John Draper, Cap'n Software]: a comment to 985

I was wondering about that, whether XMODEM would work on BIX. I also wonder about Kermit. I plan on posting another program on BIX and was considering XMODEM. Most of my Amiga programs are stored on the Mac. I find there are better modem programs; besides, I don't have a cable that can connect to the modem. Anyway, back to checking things out in preparation to the major uploading I'm planning soon.

amiga/main #1215, from dbetz

Binary Uploads
Has anyone developed a file format like BinHex on the Macintosh for transmitting Amiga binary files through phone lines? I remember that there was a problem with the file size being rounded to a multiple of 128 with cheath's TxEd editor. Has anyone come up with a general solution to this problem? It seems like it should be fairly easy to come up with a format for a file that could contain both the executable version of a program and the .info file that contains the icon and Intuition information. Has this been done yet?

amiga/main #1220, from jdow: a comment to 1215

MaxiComm supports an extended XMODEM transfer that includes in the header information the exact file length. Then the receiving computer can read the header and dutifully truncate the file to exactly the right length. They did that one right, it looks like.

amiga/main #1222, from jsan: a comment to 1220

Trouble with MaxiComm is that files uploaded with it are probably not downloadable by other XMODEM downloaders *except* MaxiComm! What my terminal does to get around this is to put a LONGWORD length at the END of the file, together with a WORD flag of $1234 after it, to make it valid. When the file is downloaded by a normal XMODEM handler, you are going to truncate it *anyway*, so those extra bytes tagged onto the end don't matter, but if you download it using a *smart* downloader that knows about the *length* at the end, then it will automatically *save* only the correct length of the file, transparently to the user!

I feel my answer to the length problem is better than MaxiComm's, which effectively renders the file incompatible with other XMODEM downloaders, unless I'm much mistaken.

amiga/main #1223, from jdow: a comment to 1222

The method MaxiComm uses is very similar to the extended XMODEM used in many modern implementations. The recent C-language one in *DDJ* for June had this. One full record (128 bytes) is so allocated. It is predictable and removable by a similar smart file diddler as yours and a good deal more robust method for detecting it is there.

amiga/main #1224, from jsan: a comment to 1223

Yes, the protocol for adding a 128-byte block is based on MacBinary's

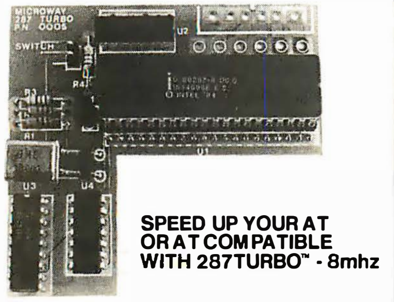
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efforts. It's known as ABTF (Atari Binary Transfer Format) on the Atari SIG and will be similarly defined on the Amiga SIG on CompuServe.

However, if a 128-byte block is added to the beginning of a file, it's not automatically removed by terminal programs that don't know of its existence. The point about adding *file information* to the *end* rather than *beginning* of the file is that it's more useful because a *normal* XMODEM downloader can successfully download the file, whereas, when you add things to the *beginning*, you restrict the downloading of the file to packages that *know* about the extra 128-byte block tagged onto the start!

amiga/main #1225, from dbetz:
a comment to 1220

How do we make use of that format on BIX? Does it look like a normal XMODEM transfer until it hits the Amiga? In other words, is the header part of the protocol part of the packet or part of the first data packet?

amiga/main #1226, from dbetz:
a comment to 1222

I still think it would be nice to have a file packer that would allow the executable file and the .info file to be transmitted as a single file and split at the destination.

amiga/main #1228, from jsan:
a comment to 1225

The ABTF protocol, as used by MacTerm and (I believe) MaxiComm, has the initial block (block 1) containing header information that includes filename (as stored on disk), real length, type of system to run on, and other useful information. It can be downloaded by *any* XMODEM downloader, but the file must be doctored at the receiving end to utilize the header information. Alternatively, a suitably equipped downloader can download and make use of the header in one big *job*, which is what I assume MaxiComm does.

My point is that although ABTF protocol is nice (and I shall be adopting it, too), it is not the all-singing wonderful gift to downloaders, because we have many existing XMODEM downloaders who will be able to download ABTF files and won't use them because they won't know how to doctor the file upon receipt.

Whereas, if the file info block was attached *to the end* of the file (rather than the beginning), then the file can be downloaded by "dumb" XMODEM downloaders, and the normal procedure of simply *chopping* the file to the correct length (as already practiced in the Amiga community) will work fine, and no garbage will prevent the file being used as soon as it's downloaded because all the garbage is at the *end* of the file, rather than the beginning. Naturally, a suitably equipped downloader that *knew* about the info block at the end would utilize the information contained therein and would save the file automatically with the correct length.

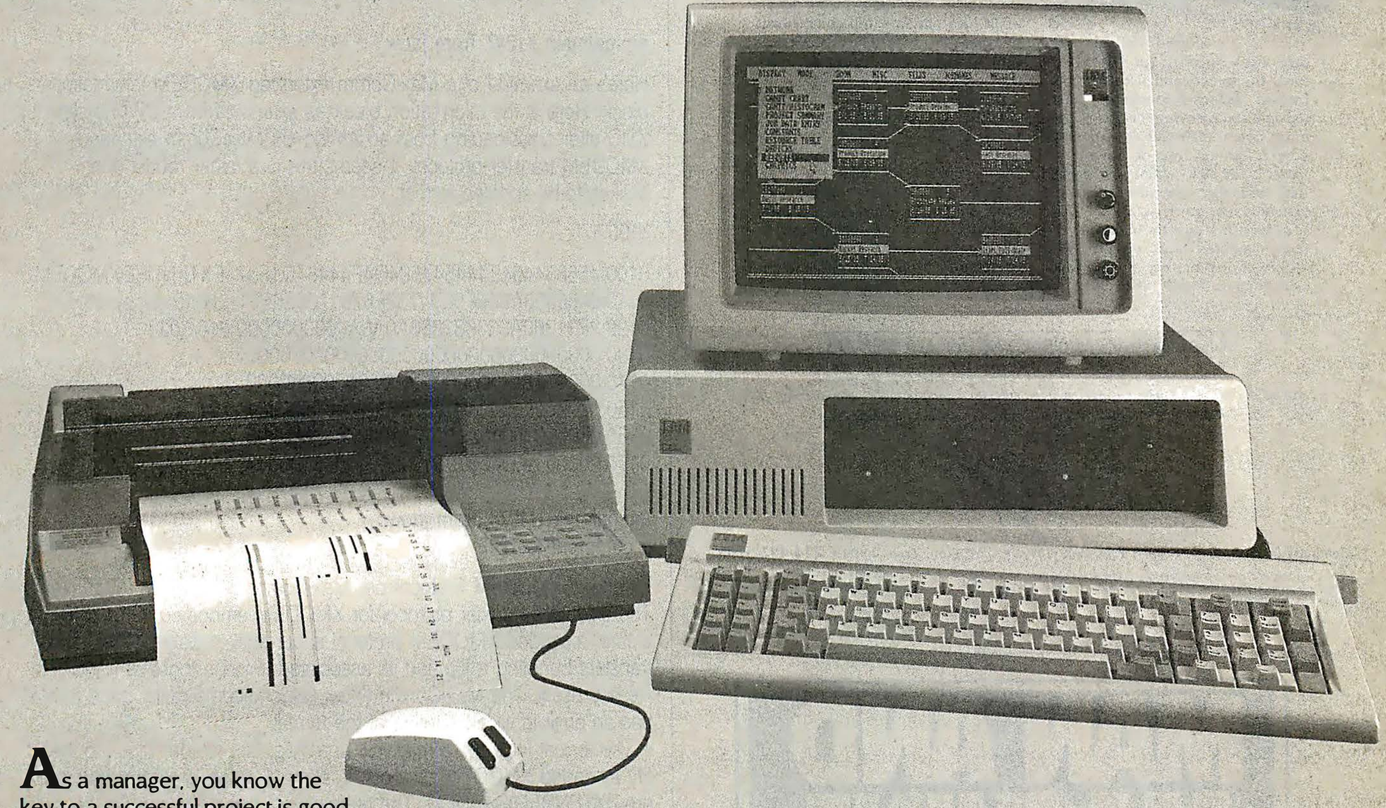
I want to confirm that *both* protocols (ABTF and the other one) are able to send and retrieve XMODEM files onto *normal* systems, like BIX, CompuServe, etc. The only difference being extra "data" added to help the host computer determine the correct length of the file, since XMODEM always rounds the length up to the next nearest 128-byte multiple.

ABTF contains other goodies, too, all 128 bytes' worth. In fact, 124 bytes' worth, because the last word of ABTF contains a checksum of the first 124 bytes, allowing it to safely determine whether a file is ABTF or not! Hmmm, I begin to wonder, actually!

If the first sector of a file was all zeros, then the checksum of *all zeros* is indeed *zero*; thus, when ABTF downloader looks for its

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checksum and validates it, then it may mistakenly think a file is ABTF when it was really *supposed* to be all zeros!

Hmmm, food for thought. I'll ask Russ Wetmore what he makes of that and see if he has a nice way of working around it.

amiga/main #1247, from jdow

Here's an example of a MaxiComm extended XMODEM information block. Here is the information block as examined on a CP/M system by ZSID after crossloading from an Amiga via MaxiComm extended XMODEM transfer protocol. It seems this is a rather robust and unlikely-to-be-spoofed format.

```
d100 17f

0100:455854454E444544584D4F44454D1F37  EXTENDEDXMODEM.7
0110:6466303A666F6E74732F6761726E6574  df0:fonts/garnet
0120:2F31360A333032380A0A0000000000 /16.3028 ...........
0130:00000000000000000000000000000000   ................
0140:00000000000000000000000000000000   ................
0150:00000000000000000000000000000000   ................
0160:00000000000000000000000000000000   ................
0170:00000000000000000000000000000000   ................
```

amiga/main #1278, from jdow:
a comment to 1247

Extended XMODEM Protocol per MaxiComm

The extended transfer protocol for XMODEM embodied in the MaxiComm extended XMODEM protocol is currently capable of single file transfers bundling a file and its associated .info file together if the .info file is present. The MaxiCorp manual (which seems pretty good to me) has an error in its description of the format.

The format includes a relatively unambiguous header block to identify extended XMODEM protocol. It takes 16 bytes, of which the first 14 are EXTENDEDXMODEM. The remaining 2 bytes are in order, send 1F and 37 (hexadecimal). This is at odds with the manual, which accuses these bytes of being 0FF and 0 (hexadecimal), respectively.

Following this are up to four strings defining the filenames in the sending computer and the exact file lengths as existing on the sending computer. These are sent in sequence as follows, with each string terminated by a single linefeed, <LF>:

FileName<LF>
FileLength<LF>
InfoFileName<LF>
InfoFileLength<LF>

The lengths are sent as ASCII strings representing the decimal number of bytes in the file as present in the sending computer. The remainder of the first block is padded with ASCII <NULL> characters to fill out the 128-character block. The .info file data is only present if there is an .info file included in the transfer. The last block of the file sent is padded with ASCII <NULL> bytes to fill out the last 128-byte block. Following this, the .info file blocks are sent similarly padded in the last block.

Another ZSID dump of the header block for sending the Amiga clock program and its .info file via MaxiComm follows:

```
d100 17f

0100:455854454E444544584D4F44454D1F37  EXTENDEDXMODEM.7
0110:6466303A636C6F636B0A31373038380A  df0:clock.17088.
0120:6466303A636C6F636B2E696E666F0A34  df0:clock.info.4
0130:33340A00000000000000000000000000   34 ..............
0140:00000000000000000000000000000000   ................
0150:00000000000000000000000000000000   ................
```

(continued)

```
0160:00000000000000000000000000000000  ................
0170:00000000000000000000000000000000  ................
```

I hope this helps all you who wish to use it. There may be a good reason as I am shortly after this uploading the SQ.C, USQ.C sources in normal format for a CP/M upload to BIX. The SQ and USQ binary files will be sent binary to BIX in the MaxiComm extended format. Enjoy!

FLOPPY-DISK HACK

amiga/tech.talk #272, from fgentges [Frank Gentges]

Amiga 5¼-inch Drives
The Amiga uses a 3½-inch double-sided disk drive as its internal drive. It is an NEC FD1035. The electrical interface is the same as a 5¼-inch drive. The disk format is 80 tracks per side. A 5¼-inch quad-density drive can support an identical format; thus, if substituted for a 3½-inch external drive, the Amiga and software should not be able to discern the difference.

Problem #1. The connector is a DB-23 rather than a DB-25. This can be solved by using a metal shell DB-25 and cutting and bending the shell and cutting off pins 13 and 25. Pins 14–24 now renumber to pins 13–23. I built it and it works.

Problem #2. There are two Amiga signals that don't match up with a standard drive:

Amiga pin 10 designated DRESB*
Amiga pin 11 designated CHNG*

Can anyone shed any light on what these pins do and what kind of signals the drive should accept or generate? DRESB* appears to be an Amiga output and CHNG* appears to be an Amiga input. I think I have all the other pins worked out and will be glad to share the info.

amiga/tech.talk #273, from jmeyer [James Meyer]:
a comment to 272

Amiga pin 10 clears a latched motor; pin 11 indicates that a disk has been ejected. If you leave pin 11 unconnected and change disks, the Amiga will tell you that you have a corrupt disk.

amiga/tech.talk #278, from ripley [Mike Riley]

Disk-Drive Connector
Could someone in the know please post the pin-out of the disk-drive connector? I copied a couple of pages from the hardware manual, but all the pins were listed by *letters*. I would like to whip up a cable this weekend to add some 5¼-inch drives. Any help would be appreciated.

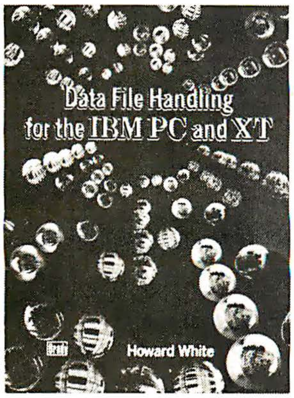
amiga/tech.talk #279, from jmeyer:
a comment to 278

Pin 1	ready
2	read data
3	ground
4	ground
5	ground
6	ground
7	ground
8	motor (signal should latch!)
9	drive select c
10	motor clear
11	disk change (indicates ejected disk)
12	+5 volts
13	side select
14	write protect

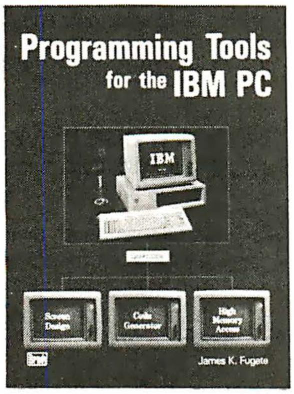
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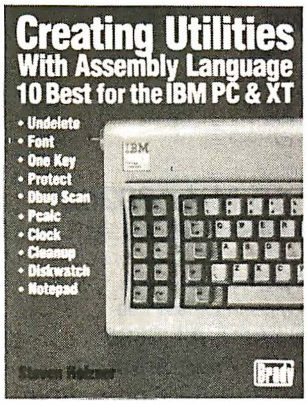
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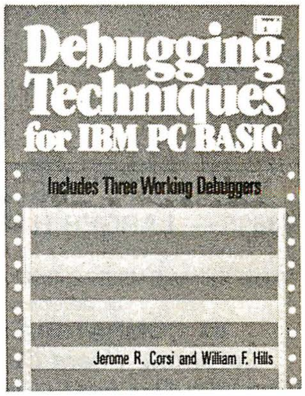
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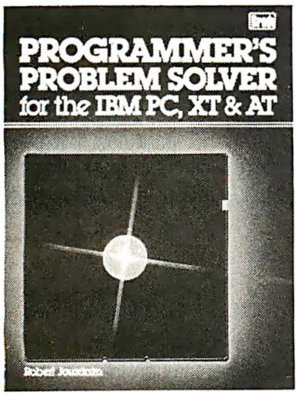
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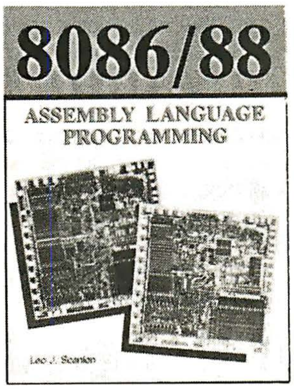
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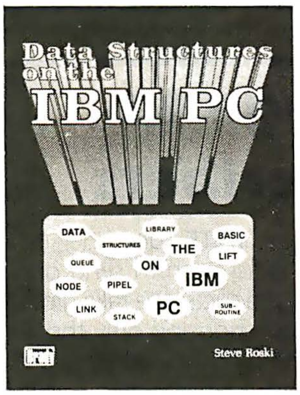
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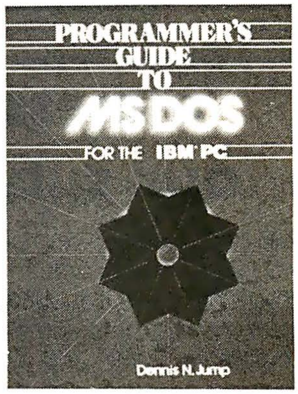
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17 write data
18 step
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20 drive select d
21 drive select b
22 index
23 + 12 volts (only enough for one 5¼-inch drive)

Thanks to Jay over on CompuServe for this info.

BERNOULLI DISK DRIVE

amiga/main #986, from mposehn [Mike Posehn]:
a comment to 975

20 megabytes isn't much on a graphics machine like the Amiga. I'm going to wait for 40 megabytes.

amiga/main #991, from skipcave [Ellis "Skip" Cave]:
a comment to 975

I would suggest that you take a look at the dual 20-megabyte removable cartridge drive from Iomega (New Bernoulli Box). This box gives you 40 megabytes on line with 35-ms access times, fully removable media, and a 3–4 minute backup from one cartridge to the other (20 megabytes). The box has a standard SCSI parallel port and I have driver sources for the 68000 on various machines with SCSI ports. You can turn most any 8-bit port with some handshake lines into an SCSI port without too much sweat.

I have 15 or so programmers developing with the dual 10-megabyte versions of this box, and the easy backup is a developer's dream. (I don't know how often *you've* blown up the OS on a new machine and lost hours of work, but the instant backup feature of these things is invaluable.) The box is a bit pricey ($2000 and up) but nothing beats it for developers.

amiga/main #1017, from ripley:
a comment to 975

What I want is an SCSI host adapter that allows me to use several hard-disk controllers and tape backup units through the same interface. The DMA would be on the host adapter and the software should allow you to configure for *any* size Winchester including a mixture on a single controller. Even the controller ID could be specified.

Don't forget, one of the things a lot of companies at COMDEX were showing were hard disks (including 360-megabyte 5¼-inch drive) with the SCSI interface built into the drive. So allowing for several controllers might not be a bad idea, as each of these drives uses a separate controller.

Besides, I have an ulterior motive. I picked up several of my company's used Winchesters and controllers with cabinets for $40–$45 for 5-megabyte and 15-megabyte drives. I would like to add these to my system, along with the Tandberg streamer I can get through the company at cost. Also, the CD-ROM drives should be controllable using SCSI controllers, I believe. By using this interface I don't see how you can go too far wrong. With a single host adapter you can add a myriad of different mass-storage devices using controllers designed by companies that specialize in that field (I recommend OMTI and Emulex) and can produce the controller cheaply by selling to a larger market than a single computer. Also, once the adapter is purchased you don't waste slots in a chassis and other SCSI peripherals should be cheaper to add.

(continued)

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ZBasic ™	13.7 sec.	ZBasic ™	30 sec.
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10 iterations of the Sieve from Byte, January, 1983

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PRESERVING PREFERENCES

amiga/main #1173, from mbutler [Michael Butler]

Am I missing something, or is there really no standard place in RAM to squirrel away the color table?

I'm particularly interested in being able to tidy up the first four palette entries (i.e., the Workbench colors) when my code is finished running. The hardware manual says that the actual registers are write-only, and I believe that, but is there no stock way of recovering the stuff done in Preferences?

Are the contents of the disk file updated by Preferences laid out in such a way that mere mortals may view them? Are there standard symbolic names in some #include, or some such? RJ? Pariseau? Anybody?

Also, I too would *really* appreciate more documentation on device drivers and printer interfaces. There are some nifty serial chips that are crying out for a side-board.

amiga/main #1174, from duck:
a comment to 1173

Try GetRGB4 where:

(vp,index)
vp = viewport of the Workbench screen
i = 0–3 for Workbench

Returns 12-bit value.

amiga/main #1175, from mbutler:
a comment to 1174

Far out. Thanks! Could you tell me which include file that's in? Thanks again.

amiga/main #1177, from duck:
a comment to 1174

I made a mistake, I think GetRGB4 takes a color map. You can get that from viewport->ColorMap. If you can find the Workbench screen you'll notice a viewport in there. GetRGB4 is a graphics.library function.

amiga/main #1179, from rjmical [R. J. Mical, Commodore-Amiga]:
a comment to 1177

If you aren't opening a window in the Workbench screen, you have no way of getting at the screen's viewport. But there's an easier way to get the default Workbench colors:

Call GetPrefs(), the Intuition function that returns a block of data containing the current system preferences. The data structure is named Preferences (surprise! could you guess? simplicity!) and can be found in the file intuition.h. The GetPrefs() function can be found in the Intuition manual.

amiga/main #1183, from duck:
a comment to 1179

The GetPrefs function only returns the user's preferences, it does nothing to return the current Workbench screen colors if someone else has dickered with them. The GetPrefs only works for Workbench and is not able to handle any screen that you may want to restore colors to after you have changed them.

ATARI ST

This month the ST discussions concern switching resolutions, experience with different versions of C and assemblers, installing TOS in ROM, using the VT52 on the desktop, I/O on the joystick port, printers, alternative disk formats, and the limitations of ST windows. Enthusiasts of Star Raiders will appreciate Jerry's closing fervor.

SWITCHING RESOLUTIONS

atari/tech.st #143, from cheath [Charlie Heath, MicroSmiths]

Is it really impossible to change from low to medium resolution on the color monitor without rebooting? It is possible to toggle the hardware, but the VDI routines will not work. We spoke to Atari and DRI and that

was the conclusion. This means it is impossible for a program to switch between a 16-color low-res graphics display and an 80-column text display. We are shocked, as our current contract job requires the switch.

atari/tech.st #144, from jtittsler [Jim Tittsler, Atari Corp.]: a comment to 143

You might try doing a close physical workstation call after you have toggled the hardware (with the extended BIOS function call). Then reopen a physical workstation, and theory says VDI will catch on to the new resolution. (This should work within your application, but exiting to the desktop after doing this may be a problem.)

atari/tech.st #146, from jsan [Jez San, Argonaut Software]: a comment to 143

It's perfectly possible for a program to change between low-res and hi-res quickly and easily. All that is required is a quick mode change on the system register "shiftmd" (Video Shift Mode type).

This is perfect for a hardware point of view, and we use it in our game. The problem comes when you want to use GEM, which was not designed to work in multimode environments! I'm sure someone will figure out a "naughty" (dirty) way of poking GEM's variables to fool it into changing modes, but in the meantime, I know of no *legit* way of doing it.

atari/tech.st #150, from cheath: a comment to 148

Re: Switching resolution. We tried the "Close workstation; set hardware to other mode; Open workstation," and it doesn't work with the VDI routines.

I/O OPERATIONS

atari/tech.st #50, from skrenek [Steve Krenek]

Can the ST do anything during an I/O operation (like the Amiga) or does it wait until the I/O is complete to proceed (like the Atari 800)?

atari/tech.st #145, from jtittsler: a comment to 50

Yes, the ST can do some operations during disk I/O operations. This is due, at least in part, to the way the DMA chip buffers the data arriving from the disk (either through the internal floppy controller or the external DMA port). It will request the 68000 bus only when it needs to empty its internal FIFO, leaving the 68000 largely unencumbered even during DMA.

Cs AND ASSEMBLERS

atari/tech.st #205, from alovejoy [Alan Lovejoy]

I would like to know what compilers are available and about their quality.

atari/tech.st #208, from neilharris [Neil Harris, Atari Corp.]: a comment to 205

C compilers: Alcyon C, sold directly by Atari as part of developer's package.
Hippo C, from Haba Systems.
Lattice C, coming soon from Metacomco and sold by Antic in the U.S.
Megamax C, almost out.
Modula-2: TDI Systems, Dallas, TX (written in England).
BASIC: FAST/BASIC, coming soon from Philon.
Pascal: Personal Pascal from OSS, native-code compiler.

atari/tech.st #149, from wbaker [Bill Baker]

I have given up on Hippo C. Bugs, fairly slow, and almost no documentation. Just received an early copy of Megamax C. So far it looks very good.

Programs written for DRI C work perfectly. Compiles are fast. Comes with a graphical shell. (Although the linker will not work under the shell if you are using double-sided drives.) Am looking forward to the final release.

(continued)

atari/tech.st #204, from dmenconi [Dave Menconi]

TITLE: Micro C Shell
For you UNIX fans out there, there is a relatively new product out called Micro C Shell. It is a C shell that sits on top of TOS and pretends it is UNIX. I have talked to the people at Beckemeyer, and it sounds like it is well worth the $50 they want for it. It does pipes, script files, redirection, and aliasing and has about 25 of the standard UNIX commands as well as a partial library of C utilities.

The $50 product doesn't do multitasking, but they are coming out with a multitasking add-on for extra money ($100?—only approximate) that will.

If you are interested, you should contact

Beckemeyer Development Tools
592 Jean St., #304
Oakland, CA 94610
(415) 658-5318

atari/tech.st #170, from cheath:

I thought the Lattice Amiga compiler had problems, but now we're trying to port stuff from Amiga to Atari, and the Atari compiler generates pseudorandom structure addresses! We're having to convert all structure references into explicit offsets. This is an exercise in high productivity. (It's a good thing the Amiga isn't using this compiler; with all the wonderful Amiga data structures, it would take years to figure out what was wrong!)

atari/tech.st #171, from jsan:
a comment to 170

Metacomco have finished their Lattice C for the Atari ST, which is currently in beta testing at this very moment. If you want compatibility between your Amiga and Atari programs, then you could do worse than use the same C compiler—Lattice.

atari/tech.st #211, from jsan:
a comment to 206

I have used the Metacomco assembler. And it's very slow, but very good and full-featured.

I then went on to use the Kuma Seka assembler, on sale from Antic in the U.S. It's *very, very* fast at assembling but lacks most of the features of Metacomco's. However, it *does* have an integral Debugger and Environment (Shell!?) that makes it useful!

Assembly times of my program (back in the days when it was only 100K bytes of source code) were 30 minutes for DR assembler, 20 minutes for Metacomco assembler, and 6 seconds for Seka! Yes, 6 seconds! It accomplishes this because the file is loaded into RAM before assembly. All editing and other functions are done with the file intact. Also, Seka needs no stupid RELMOD program; its output is runnable immediately.

On a 512K-byte machine, it's unlikely you will manage to fill memory with your source file.

There is one further assembler out, which I consider the best of the lot! It's HISOFT's DEVPAC! Phone them in Dunstable, England; number (582) 696421.

It's as fast as Seka but has fewer disadvantages. First, it runs properly with GEM and has a *nice* decent editor. Next, it allows include files, so you are no longer limited by memory size.

There is also a GST assembler coming out, which, knowing their reputation, will *also* be pretty good.

atari/tech.st #151, from qpro [Christina Willrich and Richard Man]

In *Analog*, Tom Hudson did an article on the Mandelbrot set. His DRI C program produced a low-res picture in 20-45 minutes. My back-of-envelope calculation shows that an average picture takes 20-60 million floating-point operations. A friend has written a Mandelbrot program in Amiga BASIC that takes 3.5 hours to do a picture. Since this is a calculation-intensive program, the difference between interpreter and compiler should not be that great. Also, my friend is using the fast floating pointer in his Amiga. What gives?

atari/tech.st #152, from dmenconi:
a comment to 151

It is true that, once the interpreter figures out what the calculation is, the actual calculation will take roughly the same time whether the program is BASIC or C. However, the overhead involved in setting up for each calculation is not trivial. Also, there is the looping and the condition testing, not to mention storing and retrieving data. Given all this I am not much surprised at a 7 to 1 improvement of C over BASIC. In fact, I would expect more. Either the Amiga BASIC is very good or, as you suggest, the type of problem is slightly better suited to BASIC.

Since the two processors are the same and the machines are not doing graphics in real time (I assume), the difference in the two computers would be the language and the clock speeds (I think the ST is a smidge faster, isn't it?) and, of course, how the two programs are written. I would say that there are too many variables to use this as a comparison between the two machines.

atari/tech.st #154, from cheath:
a comment to 153

I'd expect the Atari to be about 5 percent faster if they use the same floating-point routines, on this nongraphic-intensive application. If there are moving images on the screen, the Amiga is 2 to 5 times faster, from our limited experience.

atari/tech.st #155, from skrenek:
a comment to 154

I was surprised that the Amiga came out faster than the ST on this timing. The pixel drawing to fill the screen should be such a small part as to be unimportant. I also would expect the ST to be faster on the pure math. There were some slight differences because of the way the libraries are accessed. In fact, now that I think about it, Tom may have said that the square root function is double precision on the ST.

atari/tech.st #156, from jsan:
a comment to 155

In some ways, even without hardware assistance, it is easier to draw a pixel on the Amiga than it is on the Atari. The Amiga has the most logical video bit-plane logic of all—pure contiguous memory.

The Atari utilizes interleaved bit planes, which, although useful on occasion, make it slightly slower when doing raw graphical functions, like line drawing or pixel plotting.

The Amiga clock speed is 7.2 MHz, whereas Atari's is 8.0 MHz. Having said that, Lattice C, the standard on the Amiga, may be producing tighter code.

A better benchmark would be using the Green Hills C that Amiga themselves use. I've been told that it produces real quality code, which runs much faster than Lattice or any of the others.

Incidentally, I would be interested in someone writing *exactly* the same program on both the Atari and Amiga machines—and even using the *same* compiler. This is now possible because Lattice C has

been written on the Atari ST by Metacomco. It's at the beta-testing stage but should be released shortly.

I think the bottom line is that anything involving *graphics* will be inevitably faster on the Amiga due to hardware graphics support and more logical screen memory, but that in raw processing, the Atari will be very slightly faster than the Amiga.

Having said that, in the *real world*, no program does raw processing without *some* screen interaction. *All* programs have text or graphics routines in abundance, which is, of course, where the Amiga excels. Real world is what counts, and so it's likely that most real-world application programs will apparently run faster on the Amiga.

TOS IN ROM

atari/non.tech.st #125, from dmenconi:
a comment to 124

I have heard (and would like to verify) that the users groups will get the ROMs (EPROMs, if you want to be picky) soon now with the understanding that they should copy them as needed.

atari/non.tech.st #127, from neilharris:
a comment to 125

Users groups who bought STs directly from Atari will get one set of ROMs (*not* EPROMs) per machine purchased, when available (probably January). I believe that we will allow people to copy them on EPROM for members. Otherwise, dealers can install the ROMs. The suggested price is $25.

atari/non.tech.st #141, from jsan:
a comment to 139

Developers can send blank EPROMs to Atari Tech Support and have them returned with ROM TOS on them. If in England, they can contact Computer Concepts, who are Atari's agents for distribution of the EPROM TOS.

atari/tech.st #164, from jsan

I've just received my TOS on ROM (well, EPROM, actually). It's great, being able to power up and use the machine *instantly*! Especially useful for development of my game because every time it crashes I have to *reset*. At least now I don't wait 30 seconds each time.

One thing I noticed. Colour mode has its display shifted right by a large amount. It's almost off screen compared to TOS on disk. What can I do about that?

atari/tech.st #165, from jtittsler:
a comment to 164

On the back of your "colour" monitor there is an adjustment that will permit you to center the display to your liking. When TOS was put into ROMs for the European market, the decision was made to accommodate 50-Hz PAL displays, and so it will appear shifted on your monitor as it was set up. The monitor has plenty of lock range, however, so it should be easy for you to get it centered.

atari/tech.st #167, from jsan

TITLE: U.K. ROM TOS Patch for Early Machines
Jim Tittsler—Many thanks for the help you (and Shiraz) gave me just now on the phone. The solution was to modify the 50/60-Hz flag back to 60 Hz on boot-up. The following code performs that task, as I'm sure others will be interested in a patch, too. (Although quite how many Brits there are on BIX is not the issue, hehe!)

```
;Patch to fix UK ROM TOS from having shifted display!
;
;          (c)1985, Argonaut Software Ltd., UK.
;                    By Jez San.
;
; Assemble this program, and save it as "FIXIT.PRG" inside
; the "AUTO" folder on your drive 0 disk. When UK ROM TOS
; boots up, it will execute this program, which resets the
; 50/60-Hz flag back to 60 Hz, which puts the display back in
; the centre of the screen for us early ST users. People
; lucky enough to have the recent version of the Glue chip
; will not have this problem (so I'm told!).
;
move.l #stack,sp ; TOS doesn't allow us to use its own stack, snif!
clr.l -(sp) ; Set Supervisor mode (ho hum . . . !)
move.w #$20,-(sp)
trap #1
addq.l #6,sp ; Reset the stack
move.b #$fc,$ffff820a ; Change the flag back to 60 Hz
clr.w -(sp) ; Exit gracefully back to TOS/Desktop
trap #1 ; (Did I say Gracefully!? Surely Not!)
; That's it, possibly the smallest program I have ever written!
; [Also, the first program I wrote that worked first time!]
dc.l 0,0,0,0,0,0,0,0,0 ; Call this a "Stack!"?
stack:
end
```

(continued)

VT52

atari/tech.st #185, from mofi [Ric Young]

Has anyone had a problem with the VT on the desktop? It seems to lock up for no apparent reason at all.

atari/tech.st #186, from jsan:
a comment to 185

The reason for the lockup is that the dumb ST will occasionally receive an XOFF character. This tells it to stop sending any more characters down the serial port, and hence until you receive an XON character, it will *lock up*!

The problem arises when the XOFF wasn't sent intentionally and was either sent via line noise or was in fact output by the ST but was inadvertently echoed back into the ST due to a Hayes-compatible modem that echoes its command line.

Quite simply, you're stuck!

I/O ON THE JOYSTICK PORT

atari/tech.st #212, from al [Alastair J. W. Mayer, author of BIX's CoSy software]

A question/assumption: Is the pin-out on the ST joystick port the same 9-pin pin-out as the original Atari joystick port (and the VIC-20 and C-64)?

If so, is whatever peripheral chip the port attaches to capable of both reading and writing the joystick button ports? (Obviously can't write the analog paddle ports.)

I have a Sequential Circuits plug-in music keyboard designed for the C-64. It plugs into the joystick port—it takes power from the 64 and is read by using two pins as output to clock out the key-press data in serial form through one input pin.

Can I program the ST to do the same? Or is the ST game port input-only?

atari/tech.st #216, from neilharris:
a comment to 212

It is the same pin-out as far as the digital signals are concerned. There are *no* analog inputs. Data from the joystick/mouse ports is fed into a 6301 single-chip processor, which sends data through a 6850 ACIA to the main system. More info is available in the Atari developer's kit or, at lower cost, in the book *Atari ST Internals* from Abacus Software, (616) 241-5510.

atari/tech.st #220, from jtittsler:
a comment to 212

(In addition to Neil's comments.) The ST joystick ports are the same pin-out as the older Atari 8-bit line, but they are input-only. They are sampled by the keyboard microcontroller, and packets of information concerning state change can be sent to the 68000 or the microcontroller can be interrogated about the current state depending upon what is appropriate for the application. There is also one special mode that repeatedly samples the "fire button" input of joystick 2 and packs 8 samples/byte for reporting to the 68K (this was included for a couple of potential applications that required an easy way to sample 1 bit).

atari/tech.st #225, from al:
a comment to 220

That was the impression I got from Neil's comment. The pins are read-only. Fine for joysticks and the like, but darn, I really *like* the ability to use those pins as outputs too. (On the C-64 they're wired to a 6526 interface adapter, on a VIC-20 to a 6522 [you should know that, Neil!]; thus they can be set for I or O by setting the data direction register on the chip.) I've put together a couple of different gizmos that use that ability, and the Sequential Circuits keyboard is another one.

Are there *any* programmable output ports on the ST? (Other than, obviously, the predefined MIDI and RS-232C serial ports and disk ports.) If not, how about a 6522 cartridge for the "ROM" port? (Will that work?)

Or can the keyboard microcontroller be reprogrammed? (I suspect the answer to the latter is that it would be far more trouble than it was worth, if I have to burn a new ROM for it or something.)

atari/tech.st #227, from neilharris:
a comment to 225

You can't even make a new ROM for the keyboard controller, since it is part of the single-chip microprocessor. Why not use the parallel printer port, which happens to be bidirectional?

atari/tech.st #230, from jtittsler:
a comment to 225

Yes, as Neil suggests, the bidirectional parallel printer port would be a good candidate. There are also a couple of other parallel output bits available that might serve. One bit is available on the video output connector; we intend that to be used to switch from one monitor to another, but obviously you can use it for other purposes. Another bit is available on the output port of the sound chip that is not even brought out to any connector in the current machine, so you could use it by "blue-wiring" it to the place of your dreams (only with a little bit of peril, since future machines might take advantage of that bit). You could likewise get outputs by using the 6850 modem control lines if you don't mind hacking up your ST.

atari/tech.st #231, from neilharris:
a comment to 230

Keep in mind that these suggestions violate the protocol for keeping compatible with the future. If for one person's application for one machine, fine. Definitely not a good idea for anything commercial!

PRINTERS

atari/non.tech.st #179, from dmenconi

What sorts of printers go well with the ST? Is the Atari printer the best bet or are there better ones?

atari/non.tech.st #181, from neilharris:
a comment to 179

We recommend anything compatible with the Epson Graftrax protocol.

atari/non.tech.st #180, from mofi:
a comment to 179

Well, I use my Epson RX-80 F/T+ with my ST. I went out to Radio Shake (Shack) and got the standard cable and everything works just fine. First_Word has the drivers for the Epsons, so printing is simple. I prefer Epson for dot-matrix printing to Atari printers (talking from past experience only, not present new ST printers).

atari/non.tech.st #182, from skrenek:
a comment to 179

I think my Star SG-10 looks great with the ST. (For those of us still in the

Dark Age of black-and-white print, that is!) You may still have to make your own cable, though.

atari/non.tech.st #187, from jtittsler:
a comment to 179

The pin-out of the D connector on the back of the ST was designed so that a typical PC printer cable with a DB-25P on one end and a Centronics connector on the other end would work.

atari/non.tech.st #183, from dmenconi:
a comment to 182

Is there enough documentation to figure out how to make a cable?

atari/non.tech.st #184, from skrenek:
a comment to 183

Apparently there is enough info with the developer's package. I don't know what info comes with the consumer version regarding printer port pin connections. Any consumers out there?

atari/non.tech.st #188, from bwebster [Bruce Webster, Consulting Editor, BYTE]:
a comment to 184

The 520ST owner's manual has pin-outs for all the ports in the back; see page 76 for the printer port.

Disk Formats

atari/news.st #218, from jsan

We are using a disk format on the ST that gives us 409K of storage in an SF354 disk drive!

We did this by using 1K-byte sectors, instead of the ubiquitous 512-byte sectors that everyone else uses!

I don't see why Atari uses 512-byte sectors, because the cluster size is *two*, which makes DOS use 1K-byte blocks *anyway*, so you might as well have used sectors of 1K byte, and a cluster size of *one*!

The extra 50-odd K that we get using 1K-byte sectors makes it *very* worthwhile.

atari/news.st #219, from jtittsler:
a comment to 218

Yes, there are also some folks using 10 sectors per track instead of 9. We wanted 512-byte sectors for a variety of reasons, including compatibility with some future products. But as you have obviously found out, it is not difficult to support a variety of media formats.

ST Windows

atari/non.tech.st #129, from dmenconi

Is it true that the ST does not let you arbitrarily position your icons?

atari/non.tech.st #130, from neilharris:
a comment to 129

You can put your icons where you like on the desktop, but not in the windows.

atari/non.tech.st #131, from dbetz [David Betz]:
a comment to 130

I think that it is really important to be able to arrange the icons in a disk window the way you want to. One of the things that makes the Macintosh so easy for new users to understand is that documents seem to behave as real objects. When you move a document, it stays where you put it. You can arrange your documents in a convenient order on your desk (in windows) and they remain in place from session to session. If you take away that ability, you are left with something that is no different from a traditional file system with pictures as file extensions.

Star Raiders

atari/non.tech.st #156, from tom_thompson [Tom Thompson, Technical Editor, BYTE]

Truth to the "Star Raiders II" rumor?

atari/non.tech.st #163, from neilharris:
a comment to 156

It is under development by one of our best in-house programmers. He has many of the early routines done, but it will probably be 3–4 months more work for him. Looks awesome—thanks to the ST's better resolution; the different displays from the 8-bit version are combined on one main screen. So the galactic map is displayed as a hex map in the lower part of the screen.

atari/non.tech.st #166, from tom_thompson:
a comment to 163

Thanks for the info, and keep us posted. Please don't cramp the big display too much—a lot of Star Raider's appeal came from getting involved in the big screen display. I'd like to see more sophisticated graphics (shouldn't be too hard with the ST, right?), particularly realism on the attack vessels, and more elaborate attack algorithms from the enemy ships.

atari/non.tech.st #175, from jerryp [Jerry Pournelle, Consulting Editor, BYTE]

I want Star Raiders for the ST. I want Star Raiders for the ST. I want Star Raiders for the ST. I want . . .

IBM

This month's selection of activity in the IBM conference features a continuation of the discussion about the NEC V20/V30 CPUs, questions and answers on how extended memory and memory overlays work, more comments on methods to speed up the PC AT, and a suggestion on how to extend the environment space on a PC.

V20/V30 Performance

ibm.pc/pc.hardware #370, from lconfer [Les Confer]

8088 Speedup
Does anyone know if it's possible to speed up the PC by swapping to an 8-MHz 8088 or V20 and timing crystal? How do the "turbo-compatibles" accomplish switching between 4.77 and 8 MHz? Is it possible to implement the same type of scheme in the PC?

ibm.pc/pc.hardware #372, from cjackson [Craig Jackson]:
a comment to 370

There's been some talk of this here and in the cpus/v20v30 conference. I don't think anybody here has actually done it. You can *buy* kits to perform this conversion; back of *PC Week* and back of *InfoWorld* have

(continued)

them. I expect back of BYTE will have them soon, too. There has also been some discussion on ARPANET about this, with mixed results.

ibm.pc/pc.hardware #374, from rsimonsen [Redmond Simonsen]: a comment to 372

There is a good article on V20/V30 user installation and performance benchmarks in a recent issue of *PC Magazine* (December 24 cover date) called "Turbocharging Your PC with the V-Series." The improvement is only about 10 to 20 percent overall (better on pure computational stuff). The *PC* article tells one a pretty complete story.

ibm.pc/pc.hardware #412, from dbetts [David Betts]

Still More on the NEC Devices
Here is some data that I generated testing the NEC 70108 (V20) and the 70116 (V30) on various computers. This data was prepared for an article written for the San Francisco IBM PC newsletter "Bluenotes" (published November 1985).

Three tests were performed: (1) an assembly-language program running one million pure integer ADDs and one million integer MUL instructions; (2) recalculation of a 160K Lotus spreadsheet; and (3) time to replace all the "e"s with "x"s in a 10-page document.

The times in table 1 were the result of running an assembly-language "benchmark" that performed 1 × 10^6 ADD instructions and 1 × 10^6 MUL instructions. One of each kind of possible addressing modes was used for each instruction, and the base group of instructions were duplicated 100 times in the .ASM source (using my editor) to reduce overhead.

Table 1: Execution times for assembly-language benchmark.

Computer	Processor	ADD (sec)	Speedup (% of PC)	MUL (sec)	Speedup (% of PC)
PCjr	8088	13.06	−129	22.92	−8.0
PC	8088	5.70	0.0	21.23	0.0
PC	70108	5.62	3.5	7.69	63.8
Compaq Deskpro	8086	2.80	50.9	14.13	33.4
Compaq Deskpro	70116	2.69	52.8	4.85	77.2
PC AT	80286	2.44	57.2	3.29	84.5

Times are averages of multiple runs, and the percentages are speedup relative to a straight PC. Also, I should point out the Compaq was run in its "Turbo" mode of 7.88 MHz, which "jes' natchrally" makes it faster. Finally, for comparison, I have also included times for the same benchmarks on an IBM AT and a PCjr (both unmodified).

Table 2 is the results for the recalculation of the Lotus spreadsheet.

Table 2: Calculation time for Lotus spreadsheet.

Computer	Processor	Calculate (sec)	Speedup (% of PC)
PC	8088	32.01	0.0
PC	70108	28.82	10.0
Compaq Deskpro	8086	17.15	46.4
Compaq Deskpro	70116	14.14	55.8
PC AT	80286	11.17	65.1

Again, all times are averages, etc. Table 3 is a comparison of the clocks to execute several "popular" microinstructions.

Table 3: Instruction comparison for Intel and NEC devices.

	Device			
	Intel 8088	NEC 70108	Intel 8086	NEC 70116
Instruction	Clock Cycles			
ADD mem16, reg	24	24	16	16
CALL near proc	23	20	19	16
CALL far proc	36	29	28	21
DIV (unsigned 16, integer)	170	25	162	25
INT (< > 3)	71	50	50	38
MOV acc, mem16	14	14	10	10
MOVS (single operation, word)	26	19	18	11
MUL (unsigned 16, integer)	126	30	118	3
RET (no POP)	20	19	16	15

Table 4 is the results for replacing all the "e"s with "x"s in a 10-page document. Microsoft Word was used for this, and to keep things as fair as possible, I ran the program and document out of a RAM disk on all engines tested, so disk access (very fast on the AT) would not affect the test results.

Table 4: Process time for a 10-page document.

Computer	Processor	Process (sec)	Speedup (% of PC)
PC	8088	103.51	0.0
PC	70108	94.86	8.4
Compaq Deskpro	8086	50.65	51.1
Compaq Deskpro	70116	40.82	60.6
PC AT	80286	32.87	68.2

In all cases but the assembly program test, timing was done by stopwatch. For the first test, DOS calls to the time'o'day were used.

One final word in conclusion. A scrutiny of the test results will reveal a more substantial increase for the Compaq (and/or the 8086), presumably due to the fact that the bind in speed in a PC (or other 8088-based machine) is *not* due to the processor but rather the speed at which memory is accessed.

I hope this is some help. 10–4, ovr'n'out.

ibm.pc/pc.hardware #413, from johnf [John Fistere]: a comment to 412

Your benchmarks are very interesting, but I have a different idea on how the speedup should be calculated. If the faster processor completes the task in one-third the time, it is running at 300 percent speed for a 200 percent speedup, right?

Here is how I would calculate the speedups:

Table 1: Execution times for assembly-language benchmark.

Computer	Processor	ADD (sec)	Speedup (% of PC)	MUL (sec)	Speedup (% of PC)
PCjr	8088	13.06	−56.3	22.92	−7.3
PC	8088	5.70	0.0	21.23	0.0
PC	70108	5.62	1.4	7.69	176.1
Compaq Deskpro	8086	2.80	103.6	14.13	50.2
Compaq Deskpro	70116	2.69	111.9	4.85	337.7
PC AT	80286	2.44	133.6	3.29	545.3

What do you think about those numbers?

ibm.pc/pc.hardware #418, from jdow [Joanne Dow]: a comment to 413

Why not calculate percent of PC speed?

ibm.pc/pc.hardware #426, from johnf: a comment to 418

I have no problem with that. It would mean adding 100 to the speedup numbers I posted.

ibm.pc/pc.hardware #430, from naro [Richard Naro]: a comment to 412

I would like to comment on both #412 and #413 to correct some incorrect interpretations. First, I must agree with johnf (#413); the performance increases are as he computed them. Since I have considerable knowledge about the V20/V30, let's make some comments on the validity of this set. First of all, the focus of the assembly-language benchmarks is very narrow—they do point out that certain instructions such as multiply/divide are significantly faster than on the 8086/8088. Use the Lotus/Word benchmarks to see some typical application performance.

The final paragraph is the most serious misstatement. The speed difference between the V20/8088 or V30/8086 is due solely to internal V20/V30 enhancements.

All external timing remains identical; i.e., the CPU clock speed has not been changed and there is no change in memory access time. The performance increase of the V30 over the 8086 compared with the increased speed of the V20 or 8088 is due to the bus bandwidth. Let me use the Lotus example (recomputed to use the correct percentage increases) to demonstrate.

Computer	CPU	Time	% Increase
PC	8088	32.01	0.0
PC	70108 (V20)	28.82	11.0
Deskpro	8086	17.15	0.0
Deskpro	70116 (V30)	14.14	21.3

By virtue of the 8-bit external bus width, the V20/8088 must perform nearly twice as many bus cycles as the V30/8086 to satisfy instruction fetching. These bus cycles (performed by the bus interface unit [BIU]) tend to dominate in the V20/8088 and mask the performance increases of the execution unit (EU). The V30/8086, by virtue of a 16-bit external data bus, are much less constrained by instruction fetch bus cycles—thus, running the same code, the V30 was 21 percent faster than the 8086 while the V20 was only 11 percent faster than the 8088.

One last note—for interested parties, there is a conference (cpus.v20v30) devoted solely to the NEC V-Series.

EXTENDED MEMORY

ibm.pc/pc.hardware #546, from jerryp [Jerry Pournelle, Consulting Editor, BYTE]

Extended versus Expanded Memory

I would greatly welcome a good summary of the differences between "extended" and "expanded" memory, the advantages/disadvantages of each, and what software is doing what with which. Since this may well have been done here already, I guess I am really asking for a favor: Perhaps it would be better done by mail? Or put into the tojerry/chaos conference so that the PC conference old hands won't be bored by it?

I really know little about it. We have an Orchid Conquest board that is "expanded" memory and seems to have several major software houses supporting the EMS "standard"; this thing works the way most Orchid stuff does, which is very well once you get it installed, and installation is easy once you catch on to what they're doing.

Alas, the Conquest doesn't exactly work with the Orchid Turbo-186 in that programs being run under the Turbo mode can't access the expanded memory.

This whole thing confuses me; I am sure that it has been explained many times and in many places, but, unfortunately, I have only limited time to read everything, sigh. Help would be appreciated.

ibm.pc/pc.hardware #556, from conniek [Conrad Kageyama]: a comment to 546

Let me try, Jerry, but what I say is not gospel. The expanded/extended thing is sort of messy. Extended memory is what the PC AT has, and your Kaypro 286—memory addresses exceeding 640K up to 3 megabytes. If you were to visualize a column of addresses (like a memory map), then extended memory would just continue as an extension of the top of memory on up through the ceiling. This is where VDISK resides in a PC AT. Expanded memory, on the other hand, is parallel memory, so to speak. In your picture, it would be a second column of memory addresses.

A little clarification here. The normal PC actually has 1 megabyte of addresses, but everything from 640K to 1 megabyte is reserved for other uses (video, etc.). So now you have these two columns (memory maps). While extended memory is a continuation of the first column, expanded memory is a parallel column, and the EMS standard physically swaps pieces of the first column with those of the second column; i.e., you load a program in the lower 640K, then swap it out with another chunk of memory from expanded memory to load another program. Clear as mud? It may be a travesty to say so here, but not long ago, *PC Magazine* had a nice picture of the way it was done, discussing the virtues of the various systems, the LIM EMS and the AST superset EEMS.

DEBUG FILE-SIZE LIMIT

ibm.pc/pc.software #489, from jms [Joseph Subitowski]

Can anyone tell me if there is a file-size limit when using PC-DOS Debug? I was attempting to debug a 12-megabyte database index file today and kept getting a divide overflow. All other files I tried worked fine but not this monster. I assume there is a file-size limit then, no?

ibm.pc/pc.software #490, from jrobie [Jonathan Robie]: a comment to 489

Debug is a .COM file, so it is limited to 64K data and 64K code unless it uses overlays.

ibm.pc/pc.software #491, from barryn [Barry Nance]: a comment to 489

Yep. The maximum number of sectors that can be loaded with a single Load command is 128 (hexadecimal 80).

ibm.pc/pc.software #494, from rschnapp [Russell Schnapp]: a comment to 490

I doubt that .COM limitations are the problem. I've loaded some pretty large files with Debug, 300K and more. Sorry, jms, I've never even seen a 12-megabyte file, much less played with one. That's a whopper!

ibm.pc/pc.software #495, from cjackson: a comment to 489

Debug is trying to load the entire file into memory, so you won't be

(continued)

able to use it for a 12-megabyte file. There may be a limit short of the size of memory; many early programs had problems at 512K because the value of a segment register at that point goes negative if you incorrectly treat it as a signed number. But I wouldn't expect Debug to have that problem.

MEMORY OVERLAYS

ibm.pc/pc.software #504, from jhchan [John Chan]:
a comment to 490

I've heard a lot about memory "overlays." Would someone tell this neophyte what it is, and where I can find more info and learn about it?

ibm.pc/pc.software #505, from bbrown [Bob Brown]:
a comment to 504

What's an Overlay?
The overlay concept is a memory-management technique that lets a programmer write programs larger than the memory space he has available. That's how huge programs can run on 128K PCs. It works like this: The programmer divides his code into "chunks" or "segments" that will be used at different times during the execution of the program. For example, he might have an initialization chunk, a processing chunk, and a termination chunk, which together would be too big to fit into memory. He also writes (or the language he's working in supplies for him) an overlay handler routine.

When you run his program, what you actually execute is the overlay handler. The overlay handler loads the initialization segment and executes it. When initialization is finished, control is transferred back to the overlay handler, which loads the processing segment *on top of* the initialization segment, which is no longer needed. (That's where "overlay" comes from.) When processing is finished, the termination segment is overlaid on top of the processing code. Therefore, the amount of memory needed for this program is enough for the overlay handler and the largest program segment, rather than enough for all the routines at once. Simple, huh?

Actually, I've *over*simplified a little. The area where the overlay handler lives is generally called the "root segment," and it may (usually does) contain things other than the overlay handler code itself. For example, the data structures used throughout the program live there, as do frequently used subroutines. If the programmer is writing in a higher-level language, the language's run-time library often lives in the root segment, too. Even so, this technique can let you pack a pretty big program into a pretty small space.

If you've worked with mainframes or super-minicomputers, you've probably encountered "virtual memory." This is similar in concept, except that the management of what code is read in from the disk ("paged in") is left to the operating system rather than each individual program. There are other, more technical differences, too. But the principle remains the same. Hope this helped.

ibm.pc/pc.software #511, from bbrown:
a comment to 504

More Info on Overlays
John, I put your answer here in case others are interested. The handling of overlays is very much implementation-dependent. The concept is the same, but the details are quite different from machine to machine and language to language. Turbo Pascal has overlay features; look on page 149 of the 3.0 manual or Addendum page 2 (back of book) in the 2.0 manual. Also, read about the CHAIN and EXECUTE functions in either Turbo manual. I'm not familiar with the overlay facilities of MS Pascal, but I'll bet some BIX'un is. Watch this space for an answer.

AT SPEEDUP AND HARD DISKS

ibm.at/at.hardware #116, from star (Spencer Star]

8-MHz Crystal and Sargon III
I recently put a faster crystal in my AT so that it now runs at 8 MHz. The only game I have that runs on the AT, Sargon III Chess, no longer loads. Decathlon never worked on the AT. I'm not a game fanatic, but I would like to have chess and maybe a few others. Two questions for my friends with *business* machines. Does Sargon III work on anyone else's speeded-up AT? Does anyone have some recommendations for games that are good and that work on an 8-MHz AT?

ibm.at/at.hardware #119, from jhchan

AT Fixed-Disk Bad Sectors
I just got four AT units at work, and after using CHKDSK, all four units have bad sectors that range from 30K, 70K, 90K, to 260K. The one that has 260K of bad sectors concerns me. Would someone comment on this?

ibm.at/at.hardware #120, from star:
a comment to 119

Core, a company that makes hard disks with a good reputation, states that they keep bad sectors to less than one half of one percent of total disk space. On a 20-megabyte, that comes to 100K. I have a Core 40-megabyte that has about 250K of bad sectors, thus exceeding their specification. I think the key is that the number of bad sectors remains stable. On disks by CMI, every couple of weeks some new bad sectors can show up.

ibm.at/at.hardware #121, from jhchan:
a comment to 120

Star, thanks for your comment. Before these four units, I also have been using an AT with a CMI drive with 30K of bad sectors. It has been over two months, and no increase in bad sectors. One of the new ATs in this batch does not have a CMI drive, but some other might. I could not see any label on the outside at all. Is there a good way to exercise that drive to check it out?

ibm.at/at.hardware #122, from mellon [Ted Lemon]:
a comment to 121

The IBM AT Advanced Diagnostics provides a way of checking your disk for physically bad sectors (as opposed to sectors that MS-DOS *thinks* are bad). Of course, be sure to back the disk up first, since all data is erased.

ibm.at/at.hardware #124, from asantic [Alexander Santic]:
a comment to 123

I've heard several mentions of the IBM Advanced Diagnostics disk. Is this sold through the Product Centers, or what? I haven't encountered it.

ibm.at/at.hardware #125, from star:
a comment to 124

My ComputerLand service center has the Advanced Diagnostics disk. I believe it comes with one of the maintenance manuals, but I'm not sure. I seem to remember trying to order it and being refused, but maybe I decided not to place the order because the price was too high.

ibm.at/at.hardware #126, from jhchan:
a comment to 125

I have an Advanced Diagnostics disk for the XT, but I don't know if it

will work on the AT. They're available at the IBM Product Center for about $300 U.S. As long as it is not from my own pocket, I think I'll get it. But it is annoying to have over 200K of bad sectors.

ibm.at/at.hardware #128, from dono [Donald Osgood]: a comment to 126

The AT Advanced Diagnostics disk is different from the PC XT disk. I tried to use the PC XT disk on the AT, but it didn't help with hard-disk formatting and checkout.

ibm.at/at.hardware #129, from jhchan: a comment to 128

I spent $295 at the IBM Product Center for the AT maintenance and service manual. After half an hour, the number of bad sectors did not go down a bit. Well, at least I didn't cut anything or screw up the disk controller. I should have listened to the earlier comments and left it alone.

ibm.at/at.hardware #134, from barryn: a comment to 133

Which BIOS service routine or interrupt contains the nasty timing loop in question? Maybe it would be possible to write a new routine, sans the stinky code, and replace the interrupt vector to point to the new routine. If the old routine isn't exercised at boot time, maybe the new routine could "sneak into place" via the AUTOEXEC.BAT file and the now-faster 80286 would never know the difference.

ibm.at/at.hardware #139, from star

How about some information on this 80286-8 CPU? What is it, who sells it, what is involved in putting it in an AT, what happens to disk accesses, chip temperatures, etc? I know there is no such thing as a free lunch. What's the downside of this miracle chip?

ibm.at/at.hardware #141, from rpluzak [Richard Pluzak]: a comment to 139

No miracle—just a faster CPU chip guaranteed by Intel to run at the stamped speed (i.e., 6 MHz, or 8 MHz, etc.). However, Intel rates conservatively (by as much as 50 percent), which means the part should run 30 percent faster with no problem. Therefore, a 6-MHz part may run as high as 9 MHz if thermal runaway doesn't occur (might need better heat sinking). The 80286-8 could probably be pushed beyond 10 MHz, maybe as high as 11 MHz, but I doubt 12 MHz.

At these speeds, however, the RAM access time becomes too long, even with one wait state inserted, forcing RAM chip swaps (to 100–120 ns). Also, other motherboard and bus factors come into play, but the board may do 12-MHz system clocking (24-MHz crystal).

I'll have to try this soon, unless someone else has.

ibm.at/at.hardware #144, from leroy [Leroy Casterline]

Some software protection schemes are sensitive to the AT speedups. If you have to run protected software, invest in one of the many crystal switches on the market. Allows operation at old 6-MHz rate at the flip of a switch. I think these products are generally much overpriced, but if they solve a problem...

I've been running my AT at 9 MHz (18-MHz crystal) with the original 80286-6 for over a year with no problems at all. Some complain of problems with the floppy disk at this speed, however (intermittent "abort, retry, ignore" messages; no damage). I use my AT for software development and find the extra speed *well* worthwhile. If you don't replace the 286, the investment is $50–$100 for the switching scheme. The faster crystal itself is available at electronics stores (in Fort Collins, Colorado, at least) for $2.50 and can be replaced with no tools/soldering in about 30 seconds once the cover is removed. Just plugs right in. Save the old crystal to swap back in case warranty service is needed.

ibm.at/at.hardware #146, from star

Adam-Orian Industries, 18045 Cocklebur Place, Suite A, Rowland Heights, CA 91748, (818) 810-8443, offers an AT Turbo card that holds three crystals with a manual switch on back of the AT (Turbo I) or through the keyboard (Turbo II). Prices are $74.95 for Turbo I and $124.95 for Turbo II. I'm thinking of getting one. Seems like the best solution.

ibm.at/at.hardware #152, from mhaas [Mark Haas]: a comment to 151

Many people don't realize that the DMA channel on an AT (stock crystal) is slower than the DMA channel on a stock PC. I believe the AT's is 3 MHz while the PC's is the same as the CPU—4.77 MHz.

ibm.at/at.hardware #153, from rpluzak: a comment to 152

However, the AT DMA channel is *word*-wide (i.e., 16 bits). A 3-MHz 16-bit channel is equivalent to a 6-MHz 8-bit channel. Therefore, the data rate (number of bits/second) is the same.

ENVIRONMENT SPACE

ibm.pc/other #38, from dmiller [Dan Miller]

Expand Environment Space?
Is there a way to expand the environment space? After loading all my DOS utility software (fansi console, util, PC-Write definition files) I get an environment full message. I have lots of RAM. Anyone got a driver utility that will expand the environment space?

ibm.pc/other #45, from conniek: a comment to 38

Depending on your version of DOS, and I highly recommend DOS 3.1 for its added functions as well as bug fixes, your environment can be fixed in a couple of different ways. There is a file called DOS31.PAT (and a later version called DOS31A.PAT that gives a patch to COMMAND.COM) that will correct the problem. Another way, in DOS 3.*x*, is an undocumented feature using the SHELL statement in your CONFIG.SYS: SHELL = C: \ COMMAND.COM /P /E:xxxx. The /E:xxxx is the undocumented feature where the xxxx is the number of paragraphs of RAM that you want to preserve for your environment.

The most positive method of fixing your environment is to patch COMMAND.COM, as this allows loading of a secondary command processor and reloading of COMMAND.COM without losing your environment space. Patching COMMAND.COM, though, is always a risky venture at best, so you must weigh the need. Using the /E switch in the SHELL statement is much safer and works fine so long as you don't overwrite the transient portion of COMMAND.COM in your daily work. One other technique, with which I am not familiar, is to load up your environment from the CONFIG.SYS (the environment is open-ended until you load a file, and executing your AUTOEXEC closes the environment), and then in your AUTOEXEC, unload it, thus leaving environment space. As I said, though, I know it's been done this way, but I don't know how to do it.

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MACINTOSH

This month in the Macintosh conference a number of technical problems were encountered and solved on BIX. A warning about using Rascal with a HyperDrive was posted, along with a code fragment for the rapid handling of dialog boxes. A debate over what constitutes a game started in the Soapbox topic, and assistance was given to a user encountering problems downloading from BIX.

MAC TO PC CONNECTION

macintosh/hardware #40, from joeleben [Joe Leben]

TITLE: Connecting Mac to PC
This is a strange one. I connected my Mac to my PC via the modem port on the Mac and the COM2 async port on the PC. All went well. I transferred files back and forth with no problems. But then I shut the machines off. If I turn on the PC first and then attempt to turn on the Mac, the Mac won't power on. No beep, no Mac face, no nothing. But if I then pull out the plug from the modem port that is connecting the Mac to the PC, the Mac magically powers on. This doesn't happen if the plug is plugged in and the PC is powered *off*. What's happening here? I can't believe that some condition at a serial port will cause a computer to refuse to power on! Is this just me? Even if I've got the cable wired wrong, this shouldn't happen. Any suggestions?

macintosh/hardware #41, from jeffjacobs [Jeff Jacobs]: a comment to 40

It is possible that noise generated by the serial port is such that there is a constant stream of interrupts, or an interrupt that generates a hard loop such that the system is "frozen"; i.e., the Mac is powered on but can't get to the code that gets everything started.

The above is just speculation, but you might check to see that the cable is grounded properly.

macintosh/hardware #42, from bvanantwerp [Bill Vanantwerp]: a comment to 40

Check the cable to make sure that pin 4 on the PC side is tied high. I had similar trouble when trying to make the Mac drive an HP Plotter. A check with a breakout box showed that the Mac constantly monitored pin 4 and, if low, would not power on.

macintosh/hardware #43, from joeleben: a comment to 41

Could be the ground; I'll check. I had a short cable and spliced in an extension between the two connectors. Chances are I didn't get the ground connected right. But a computer that won't turn on because something is weird on a serial port? That's a new one on me.

HARD-DISK PROBLEM

macintosh/hardware #49, from jeffjacobs

TITLE: MacBottom20 Problems
I just got a MacBottom20 and am having problems; after it has been on for a while, I start getting disk errors (−36) and Bombs (ID = 26, which I believe is Seg Load Failure). If I power off, the problems seem to go away; the longer it's off, the longer it runs okay when powered back on (temperature problem?).

When it first powers up, I can examine blocks with FEdit with no error, but after a while, errors start showing up, usually starting around sector 986 and "spreading" in both directions; the number of rereads keeps increasing until the Error = −36 appears.

Does anybody know what −36 is? Bomb ID = 26?

macintosh/hardware #51, from lloeb [Larry Loeb]: a comment to 49

ID 26 is failure to launch. The disk error is wiping necessary segments. I discussed this with the guy that wrote the MacBottom software, and he and I both feel your drive is mechanically bad. *But!* Try this before shipping it back. Boot on a good floppy Finder as startup. Get the disk going and recover any files you may need with data. Then wipe the disk by throwing away all volumes and files on the disk. Try to throw it all away. Then reinstall the volumes and files you want on the disk and see what happens. This is a workaround to reformat that the software won't let the user near. Try this to see if the install that you did was bad (for some reason). If errors still appear, you have a bad Rodime drive.

macintosh/hardware #52, from jeffjacobs: a comment to 51

The problems are intermittent. There is apparently an area on the disk that gets "bad" as the temperature increases. If I power off and power back on, all the errors *go away*. But after operating for a while, they reappear. That is, I can launch all the programs and examine the disk sectors with no errors after power-up, but they come back after a few minutes of being powered up.

I'd sure like to know what ERROR = −36 *really* is. FEdit says "Unspecified I/O Error."

It certainly seems like a bad (marginal) area on the disk. I am going to exchange it. I am *very* impressed with it; if I could reformat the disk, I probably wouldn't even exchange it.

There was a message on another system where the guy said that an early version of Switcher trashed application files. However, I assume that the files would be *permanently* trashed. If you get a chance to talk with your contact, ask him if he is aware of any possibility that this might be a Switcher problem (I was running 3.5), although it's very hard to see how software could cause this kind of problem.

macintosh/news #196, from jeffjacobs

TITLE: MacBottom Update
I tried the suggested technique of essentially recreating the volume, i.e., copied all files to a new volume, deleted the originals, and then copied back. Seems to have worked; I haven't been able to generate any errors out of the "bad" area. I still have those sectors "tied up," so that they don't get allocated.

I doubt if I'll exchange it, unless I have more problems.

THE MAC AND A UDS MODEM

macintosh/hardware #53, from cecpate [Chuck Pate]

TITLE: Help with a UDS 212A/D
I have a problem that maybe one of you all can help me with. I've got this 1200-baud modem from work to use, but the catch is we don't have documentation for them (we have two). Now is there anyone out there in MacLand who can help me get this puppy working? Can this modem work with anything but an IBM?

If not, what is a good modem that would also be compatible with most other computers? I need to get up with the rest of the world. I have been using an old A/J acoustic for seven years now.

macintosh/hardware #54, from tom_thompson [Tom Thompson, Technical Editor, BYTE]: a comment to 53

The UDS 212 modem is a smart modem like the Hayes, and as you

might have guessed, its command sequences are different from the Hayes. Here's a quick rundown on the commands that perform roughly the same functions:

UDS 212	Hayes	
COMPLETE	CONNECT	– response when carrier detected.
D(digits)	ATDT (digits)	– dial the numbers in string (digits).

If you have script or auto-pilot files set up for a Hayes modem, altering the two commands as shown should help. I've had to modify a Hayes script file to play with a UDS modem, and I suggest the following additions to your script files:

1. Start out by issuing a OG0EN (Opal-Green-Zero-Edna-Nancy) to the UDS. This initializes the UDS and places it in the command-ready state. Look for a prompt (:) from the UDS indicating it's prepared to accept commands. Do not pass go if you don't get this prompt.
2. I don't remember if there was a hang-up command like "+++" with a Hayes, so any hang-up sequences will have to be eliminated or modified.

macintosh/hardware #55, from cecpate

You hit it right on the bit and put a fire under my Mac. I'm at 1200 baud. Now I can let my boss know what to do with his UDS and Mac.

MacPlot Software

macintosh/prod.discussn #248, from bvanantwerp

TITLE: MacPlot
I just received a copy of MacPlot. Quite nice in many regards. The program can turn MacDraw and MacDraft documents into plots on a wide variety of plotters including the HP series, HP emulators, and many others. The program is quite good at using the Mac interface and also produces a variety of types of line and solid shadings on a variety of drawings. Now if it only did Excel graphs or did some curve fitting.

macintosh/prod.discussn #249, from kerskine [Keith Erskine]: a comment to 248

Can MacPlot work with Calcomp plotters?

macintosh/prod.discussn #250, from bvanantwerp: a comment to 249

Plotter Support
The version of MacPlot that I have will run a Calcomp 81 plotter. The professional version will support the 104x series Calcomp plotters, as well as some of the larger CAD plotters.

Rascal Language and Hardware

macintosh/prod.discussn #251, from mwelch [Mark Welch]

Re: Rascal and the HyperDrive 20
I noticed a few messages on MacQueue of great importance to people with HyperDrives. According to Leo LaPorte, sysop of MacQueue, any program written in Rascal that uses sound will *destroy* directory information on the HyperDrive 20. One person lost an entire hard disk this way. I don't know what version of Rascal this pertains to, but there are apparently several programs (one called Billiards) released as public domain that were written in Rascal and use sound, so if you have a HyderDrive 20 you should be *very, very* careful when running new public-domain software.

This is not a "trojan horse"—it appears to be a very obscure but quite consistently destructive bug.

macintosh/prod.discussn #252, from jrobie [Jonathan Robie]: a comment to 251

I'm sending a copy of message 251 to Scott Gillespie of Metaresearch. If he responds I'll also post his response here.

macintosh/prod.discussn #275, from jrobie: a comment to 251

Message 251 suggests that there is a bug in Rascal that results in the loss of directory information when certain programs are run on a Mac with a HyperDrive. This is Scott Gillespie's response:

As many of you know, the Rascal Billiard Parlour (an application written at Reed College with the Rascal Development System) has been wreaking havoc with HyperDrive 20s. I am a coauthor of Billiard Parlour, and of Rascal itself, and I would like to clarify and explain the source of the crashes.

Clarification:
1. There is no inherent problem with Rascal itself. Period.
2. The root of the Billiard Parlour crash is a bug in the HyperDrive 20 system software.
3. *Any* program (it doesn't matter what development system created the program) that uses the free-form synthesizer mode of the Sound Driver is a potential HyperDrive 20 crasher.

Rascal provides a turnkey sound library, which makes using the free-form sythesizer very simple; hence, we have written a number of programs using complex sound (such as Billiard Parlour).

The Bug:
The HyperDrive people wrote their own version of the Macintosh Trap Manager in order to allow a larger system heap, thereby allowing more drawers open at any one time. In one of the rewritten Trap Manager calls (either GetTrapAddress or SetTrapAddress, I can't remember which), register A2 is not restored to its original value upon completion of the routine.

And the Consequences:
It turns out that not very much code is affected by this bug, but the Macintosh Sound Driver is affected during the execution of free-form synthesizer mode calls. The Sound Driver, apparently, contains code that depends on the value of A2 not changing. It is not clear why there can be such terrible consequences (such as ruined directories on the HyperDrive); nevertheless, there are.

Verification:
This analysis is verified in part by the fact that Billiard Parlour (and other programs that make free-form synthesizer calls) run perfectly well on HyperDrlve 20s with new (as-yet-unreleased) HyperDrive software.

Solution:
The only total solution to the problem is to wait for the next official release of HyperDrive software—Billiard Parlour and other programs that use the free-form synthesizer will work fine on a HyperDrive with the new software installed.

You can, of course, boot your HyperDrive Mac from a floppy and then run Billiard Parlour without problems (just don't let the HyperDrive system take over).

I sincerely regret the loss of anyone's HyperDrive files as a result of running Billiard Parlour or any other free-form sound driver programs (we, too, have lost entire HyperDrive 20 systems to both Billiard Parlour and a non-Rascal synthesizer program).

(continued)

I also regret, however, that proper use of the Sound Driver in our programs for the creation of interesting and complex sounds has resulted in Rascal, and Billiard Parlour in particular, receiving bad press.

Thanks go to Jay Roth from General Computer for being so helpful in describing the bug and for letting me test Billiard Parlour with an early version of the new HyperDrive Trap Manager.

—Scott Gillespie, Reed College

DIALOG BOX HINT

macintosh/softw.devlpmt #97, from robertwoodhead [Robert Woodhead]

TITLE: A Nice Bit'o

Here is a little fragment of code that came in real handy and that might be of use to you. The idea is this: Many times, Mac programs put up a dialog box that does something and then goes away, triggering a bunch of update events that the program laboriously processes to repaint the screen. It occurred to me that *if* a dialog didn't change other parts of the screen, it would be possible to save the screen, enter the dialog, and restore the screen when disposing of the dialog. Of course, this works only on Macs with 512K or so, but it does speed up programs considerably (especially mine, which uses dialogs to run special areas of the program). I wrote two procedures, SaveScreen and LoadScreen, that do this properly. You call SaveScreen just before you allocate a dialog or window, and LoadScreen just *before* you dispose of said object. The procedures are in the responses to this note.

```
{ SaveScreen saves a Mac or Lisa screen in a handle and returns  }
{ the handle. Call this routine before allocating the window whose }
{ presence you want to mask.                                     }

FUNCTION SaveScreen:Handle;

VAR H:Handle; L:LongInt;

BEGIN
  SaveScreen: = Nil;
  IF littleMac THEN Exit(SaveScreen);    { littleMac global true if <512K }

  L: = ScreenBits.rowBytes*(ScreenBits.bounds.bottom - ScreenBits.bounds.
    top - 20);
  H: = NewHandle(L);
  IF H = Nil THEN Exit(SaveScreen);

  HideCursor;
  BlockMove(Ptr(Ord4(ScreenBits.baseAddr) + ScreenBits.rowBytes*20),
    Ptr(H^),L);
  ShowCursor;
  SaveScreen: = H

END.

{ Note that SaveScreen does not save the title bar.                }

{ LoadScreen restores the screen pointed to by Handle H and fixes  }
{ up the Window list. W is a WindowPeek to the window or dialog    }
{ about to go away. LoadScreen fixes everything so no updates have }
{ to be done.                                                      }

PROCEDURE LoadScreen(H:Handle; W:WindowPeek);

VAR R:RgnHandle; L,L1:LongInt;

BEGIN

  IF littleMac OR (H = Nil) THEN Exit(LoadScreen);

  L: = ScreenBits.rowBytes*(ScreenBits.bounds.bottom - ScreenBits.
    bounds.top - 20);

  HideCursor;
  L1: = TickCount; WHILE L1 = TickCount DO; { sync to the screen refresh }
  BlockMove(Ptr(H^),Ptr(Ord4(ScreenBits.baseAddr) + ScreenBits.rowBytes*
    20),L);
  ShowCursor;

  DisposHandle(H);

  { Now we make a copy of the offending window's structure region, }
  { zero the window's various regions so that when it goes away, it }
  { won't trigger any updates, refresh the other window's visRgns,  }
  { and, as a final touch, diddle the topmost window's highlighted  }
  { Boolean so it doesn't get repainted.                            }

  R: = NewRgn; CopyRgn(W^.strucRgn,R);
  SetEmptyRgn(W^.portVisRgn); { Some of these may not be needed }
  SetEmptyRgn(W^.strucRgn);    { but I'm too lazy to find out which, }
  SetEmptyRgn(W^.contRgn);     { when Wiz takes half an hour to  }
  SetEmptyRgn(W^.updateRgn);   { compile! If it works don't fix it mode! }

  IF W< >Nil THEN
    BEGIN
      CalcVisBehind(W,R);
      W^.Hilited: = True;   { valid only if W is top window, most likely! }
    END;

  DisposeRgn(R)

END;
```

TEXT PROBLEM

macintosh/tech.talk #119, from jba [Jonathan Amsterdam, Contributing Editor, BYTE]

TITLE: Overwriting Text

I'm having some trouble doing something very simple, and I thought someone could help me.

I'm using MacModula-2 to write a program that needs to move the cursor around the screen and write things. Sometimes it will write over something else, and I want the thing underneath to be erased. So I did a TextMode(srcCopy) (a Modula-2 function that does the obvious thing) before writing. I also called InitViewPort, a Modula-2 function that the manual says I should call after changing anything.

Now, writing a character over something does erase—but it erases way too much. Say I write "YabbaDabbaDoo," then go back to where the "Y" is and write "x." I'll get something that looks like "x   abbaDoo" except you can still see the rightmost part of the "D" from "Dabba." Can anyone explain this?

Additional notes: I am using Monaco 12, which is a fixed-width font. I checked the character widths and got 7 (except for the space, which was 8). I set the "spaceExtra" field to 0 as an experiment; it didn't make any difference.

macintosh/tech.talk #121, from rschnapp [Russell Schnapp]: a comment to 119

This isn't a MacModula-2 bug. You're pretty much calling the ROM directly. You've actually hit a bug in QuickDraw. When you use SrcCopy mode, QuickDraw erases far past the end of the string.

If you must really overwrite existing text, I'd suggest using SrcOr mode, after PaintRect'ing with the White pattern.

macintosh/tech.talk #124, from jba: a comment to 121

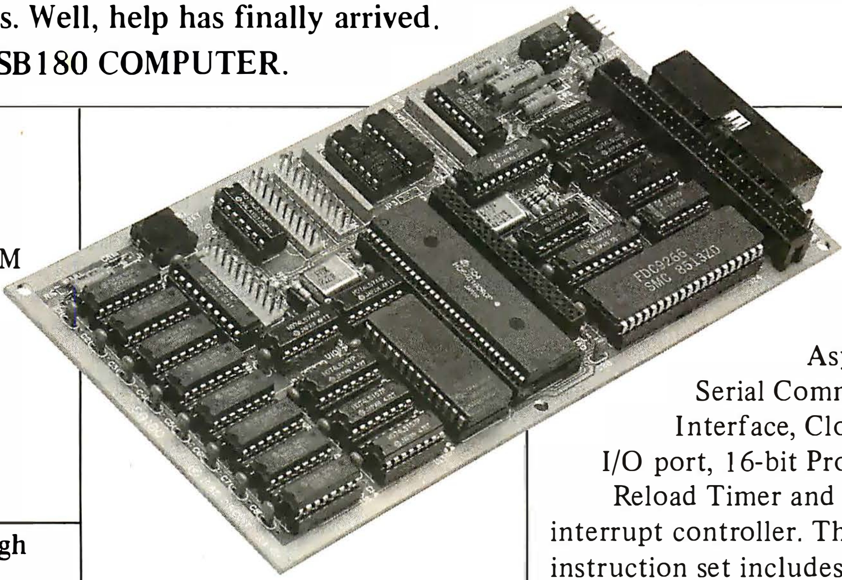
Thanks! That did the trick.

(continued)

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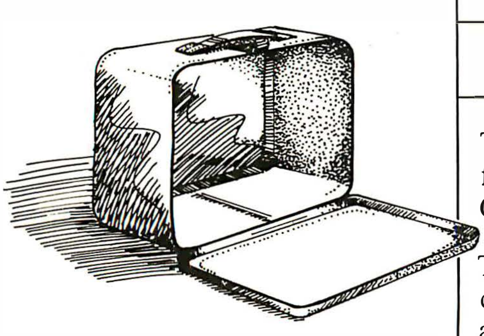
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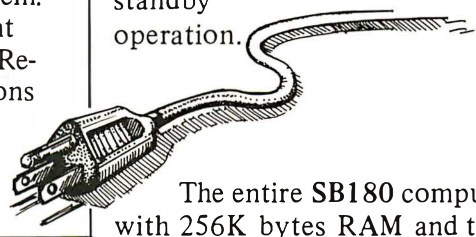
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MICRO MINT

REGION PROBLEM

macintosh/tech.talk #122, from tengel [Tone Engel]

TITLE: Region Question
I'm trying to create a region that is the union of the outlines of a number of icons. I've run into the following stumbling blocks:

1. To create a region in the shape of an icon I expected to find some kind of function for turning arbitrary bit maps into regions. No such luck. So I wrote a little function to scan the icon and draw a pixel for each pixel. This much seems to work but is awkward. Typical region size is around 200. Does anyone have a detailed description for the format of the region data? Is there an easier way to do this?
2. So now I try and union the corresponding icon regions together to get one big region, which, you guessed it, I want to pass to DragGrayRgn. My real difficulty is that this seems to work fine sometimes, and other times it crashes the system. No neat dialog, just a screen full of garbage and then a hang. This is on a 512K Mac. I've checked the heap space, 300K or so. The overall region size grows to about 640 before it dies.

Are there any limitations on the size of a region? Other than the implied limit arising from the size field being only 16 bits.
Does anyone have a clue what might be going on?
I'm doing all this in Megamax C (V2.3, I believe).

macintosh/tech.talk #123, from robertwoodhead:
a comment to 122

There is a bug in QuickDraw that crashes if a region has more than 20 or so rectangular areas on a single scan line (QuickDraw stores regions as a bounds rect that surrounds the region and *y*-sorted rectangles that comprise the region; thus your icons, with lots of little dots and white space, are represented by a lot of rectangles). This bug is fixed in the new ROMs. Suggestion: If you are going to be needing the regions of icons, what you really want to do this to is the icon Mask, which, being usually solid chunks of bits, will have fewer transitions and thus not be as likely to smash.

WHAT IS A GAME?

macintosh/soapbox #316, from dsharp [Doug Sharp]

Chris, I'm intrigued by the distinction you made (in July) about ChipWits' status as an educational product rather than a game. I have seen some ChipWits fanatics really play the thing. What would have made it a game? Why is Balance of Power a game?

macintosh/soapbox #318, from stike [Jim Stikeleather]:
a comment to 316

In the wild (nature), games and playing are very serious activities. They are nature's way of preparing (especially mammals with their extended juvenile and adolescent periods) for adulthood by developing skills (predominantly hunting and hiding) needed to survive. I think a good "human" game should do the same thing.
A good game should be educational (maybe developmental would be a better word if you want to include all the hand-eye coordination we are building in the next generation). Maybe the better the game, the more educational it appears, and the better educational systems appear more like games. Comments?

macintosh/soapbox #319, from ccrawfor [Chris Crawford]:
a comment to 316

It's been a long time since I used ChipWits, but the factor that most sticks in my mind as "ungamey" is its lack of true interaction between player and sentient opponent. It is more puzzle-like than game-like. This is not meant as a criticism—a puzzle can be every bit as worthwhile and entertaining as a game. I try to use the sharpest meanings of words that I can, and most people use the word "game" in a very broad fashion.

macintosh/soapbox #320, from ccrawfor:
a comment to 318

I agree that most good games are quite educational and have gone so far as to say that games are the original educational technology, predating schools by several million years. I would not say, though, that any good educational effort is necessarily a game.

macintosh/soapbox #322, from dbetz [David Betz]:
a comment to 319

Is the card game "solitaire" a game or a puzzle? It certainly doesn't involve a sentient opponent. I think your definition of the word "game" is too limited. Are arcade games really puzzles? They present rather simple opponents. Certainly not a sentient opponent.

macintosh/soapbox #326, from ccrawfor:
a comment to 322

Solitaire is most definitely a puzzle (in my book). Most arcade games, in my book, are also puzzles. Indeed, a great many things that other people call games I call puzzles. Now, you may well conclude from this that I have drawn my definition of the word "game" too narrowly. In defense of this strict constructionist view of games, I will point out two items: First, specialists in any field refine the language applicable to their work; note the old anecdote about the Eskimos having 7 (12? 20?) different words for ice. Two: I devoted an entire chapter of my book, *Art of Computer Game Design*, to the problem of defining the word "game." Even after an entire chapter, I did not have a solid definition, just a useful characterization.

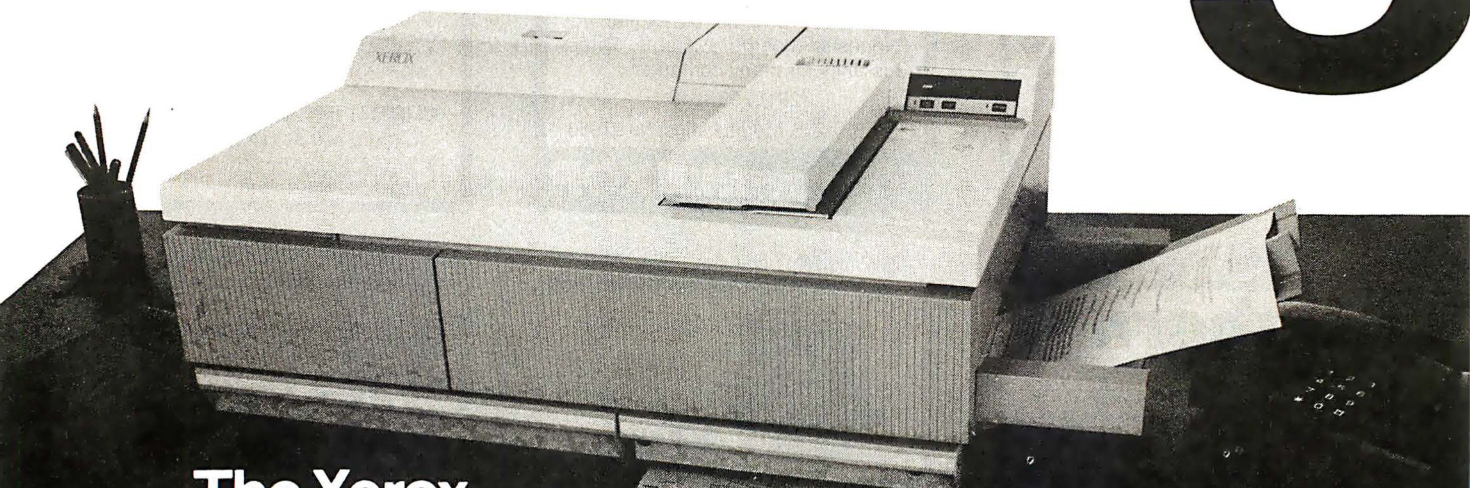
macintosh/soapbox #327, from brian [Brian Holt]:
a comment to 326

Yes, specialists do refine the language applicable to their work. When one converses with nonspecialists, it is customary not to allow redefinitions to get in the way of the conversation (i.e., who cares whether it is a puzzle or a game?). Also, the Eskimo do not have 7, 12, or 20 different words for snow. It is only an anecdote based on some unknowing anthropologists who didn't understand how word endings were being used in the language. Third, concepts such as "game" are usually not definable. Useful characterization (i.e., what everyone generally accepts) is usually the limit. Finally, ChipWits fits all of my criteria for a game, but then again, so does MacPaint.

macintosh/soapbox #329, from dsharp:
a comment to 319

The distinction you make between game and puzzle is that a game requires more than one sentient player (whether human/human or human/computer) and that the players must be opponents. ChipWits falls into the puzzle category because the computer is not an opponent.
In my usage, puzzles are a subset of games. The word "puzzles" also implies a correct solution, which doesn't fit ChipWits.
I've been calling it an educational game since I wrote it, and the only one who objected to the term was the publisher, who considered "games" too low-class to publish.
Thanks for expanding on your usage of "game." ■

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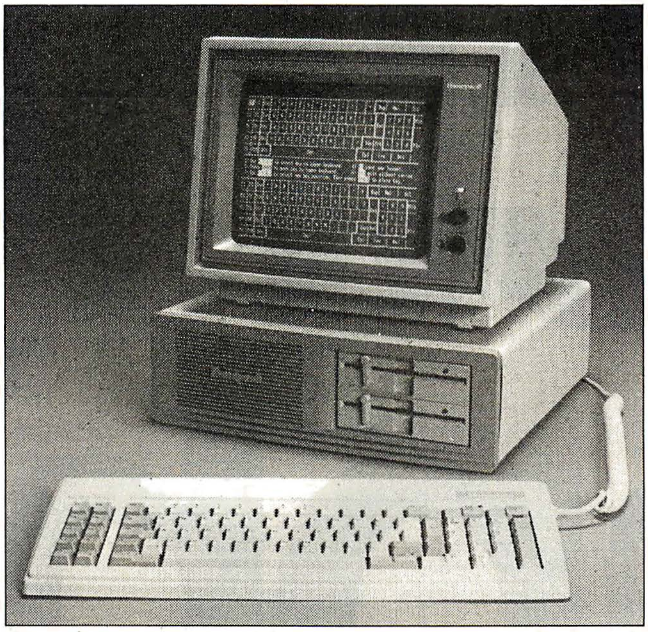
Honeywell's PC-Compatibles

The EP (Entry Processor) Series of personal computers from Honeywell includes three models based on an 8088-2 microprocessor running at 4.77 or 8 MHz. All models are equipped with 256K bytes of RAM that can be expanded to 640K bytes on the system board, a parallel printer port, a high-resolution monochrome monitor port with Hercules graphics emulation, four full-length expansion slots, and a socket for an 8087-2 math coprocessor. An RS-232C serial port is optional.

The computers are compatible with the IBM PC and are bundled with MS-DOS 2.1, GW-BASIC, the Honeywell Menu Manager, and disk-based tutorials. When equipped with a serial port, Honeywell's multifunction communications adapter, and microSystem VIP emulation software, the computers can emulate a Honeywell synchronous or asynchronous terminal.

The base model in the EP series comes with a single 360K-byte floppy-disk drive and costs $1450. A two floppy-disk model is $1550, and a single floppy-disk and 10-megabyte hard-disk model costs $2650.

Keyboards and monitors are not included. All three models can use PC-compatible keyboards, monitors, and printers or can be equipped with the Honeywell Micro Switch keyboard ($120) and Honeywell monitors and printers. Two monochrome monitors are available, with resolutions of 640 by 200 pixels ($175) and 720 by 350 pixels ($275). A 15-color RGB monitor with a resolution of 640 by 200 pixels costs $595.



Honeywell EP Series personal computer.

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The QT series of multitasking, multiuser computers supports from 4 to 20 users at prices ranging from $2095 to $8795. Nine models are currently available. All models run the OS9/68K operating system with BASIC, utilities, word-processing, and spreadsheet programs. All have a built-in hard-disk interface and take up less than 1 square foot of desk space.

The basic QT model, which supports four users and two printers, comes with 128K bytes of RAM and an 8-MHz 68008 microprocessor. The computer sells for $2095 with one floppy-disk drive. Upgraded to 512K bytes of RAM and with a 20-megabyte hard-disk drive, the system costs $3595.

The QT Plus model has a 10-MHz 68000 microprocessor and 512K bytes of RAM. It supports four users and two printers in its lowest configuration. With a single floppy-disk drive, the QT Plus is priced at $2695; with an added 20-megabyte hard-disk drive, the system sells for $3995. The QT Plus can be upgraded with an additional 512K bytes of RAM ($395) and eight serial ports.

The QT 20 model comes with a 12.5-MHz 68020 microprocessor and 2 megabytes of RAM and supports a minimum of four users and one printer. A QT 20 with a 20-megabyte hard-disk drive sells for $8795. The system can be expanded with a 16.67-MHz 68020 and additional serial ports to support 20 users. Prices for the 16.67-MHz microprocessors and additional ports were not available at press time.

Contact Frank Hogg Laboratory Inc., 770 James St., Syracuse, NY 13203, (315) 474-7856.
Inquiry 567.

Motorola VMEbus Computers

The Microsystems division at Motorola has introduced two VMEbus microcomputers that the firm claims rival VAX-11/780 performance. The System 1121 employs a 16-bit 68010 microprocessor; the System 1131 uses a 32-bit 68020. Both have hard- and floppy-disk storage, DRAM, RS-232C serial ports, and expansion slots (five for the 1121 and four for the 1131). The System 1121 can handle three users, System 1131 can handle four, and you can beef up either system with more serial ports and RAM to handle as many as eight users.

Both computers run Motorola's System V/68 operating system, which the firm claims is derived from and functionally identical to AT&T's UNIX System V.

System 1121 with the OS, 1 megabyte of DRAM, a 40-megabyte hard disk, and a 655K-byte floppy disk costs $12,495. System 1131 with the OS, 2 megabytes of DRAM, a 70-megabyte hard disk, and a 655K-byte floppy-disk drive costs $14,995. A cache accelerator and a high-speed SMD controller for these systems should be available by the time you read this. Contact Motorola, MOS Integrated Circuits Group/Microsystems, 2900 South Diablo Way, Tempe, AZ 85282, (602) 438-3000.
Inquiry 568.

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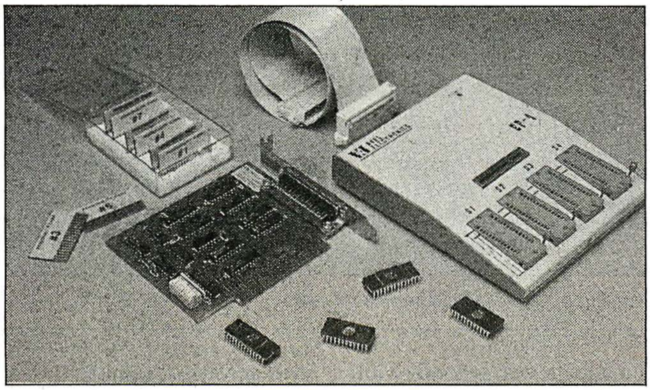
Idetix Digitizing Camera

Micron Technology has introduced the Idetix, a digitizing camera that works with the IBM PC, XT, AT, and compatibles. The camera features the OpticRAM image sensor that offers a resolution of 256 by 256 or 512 by 512 pixels.

Other features of the camera include adjustable frame size, adjustable resolution, high-speed data transfer via DMA, and up to 100 feet of cable for remote transmission. According to the company, the camera operates seven times faster than the Micron Eye digitizing camera. The company says the Idetix is intended for use in robotics, factory inspection, process control, image processing, and manufacturing automation.

The Idetix comes with a demonstration program and an assembly-language driver library with image enhancement routines. The list price is $695. For more information, contact Micron Technology Inc., Vision Systems Group, 2805 East Columbia Rd., Boise, ID 83706, (208) 386-3800.
Inquiry 569.

PROM Gang Programmer



Avel Electronics' EP-4 PROM *gang programmer.*

Avel Electronics' EP-4 is a PROM gang programmer that works with the IBM PC, XT, AT, and compatible computers. The device can program a variety of PROM types and supports 8- and 16-bit programming modes. It has four 28-pin sockets and accepts Intel MCS-86, Motorola S-record, ASCII block, and binary input files.

The EP-4 comes with software that lets you transfer files into consecutive PROMs or consecutive pages of multipage PROMS, check blanks, and verify the contents of PROMs with compare or overlay options. The software also has a full-screen RAM editor for displaying and editing RAM contents. You can use DOS commands and run application software from within the program.

When not in use as a PROM programmer, the device can serve as an extra disk drive that supports up to 256K bytes of removable PROM media. The EP-4 sells for $595, which includes the programmer, a 30-bit parallel control board, a set of personality cards for popular PROMs, a cable with two 36-pin connectors, software, and a manual. For more information, contact Avel Electronics, 3450 Murdoch Ct., Palo Alto, CA 94306, (415) 856-6504.
Inquiry 570.

Dot-Matrix Printer

Toshiba's P321 is a 24-pin printer that offers draft, near-letter-quality, and graphics printing. The 80-column printer operates at a speed of 216 or 180 cps in draft mode and 72 or 60 cps in near-letter-quality mode.

The P321 comes with a parallel interface, Qume Sprint 11 daisy-wheel emulation, and three resident typefaces; additional fonts are available on plug-in font cartridges. Graphics resolution is 180 by 180 or 180 by 360 dots per inch, and IBM graphics emulation is optional. Other options include a parallel/serial interface, tractor feed, and automatic sheet feed.

Suggested list price for the printer is $699. With a parallel/serial interface, the P321 costs $749. A downloadable font kit sells for $99, and the IBM Graphics Printer emulation kit costs $49. For more information, contact Toshiba America Inc., Information Systems Division, 2441 Michelle Dr., Tustin, CA 92680, (714) 730-5000.
Inquiry 571.

Tape Backup for Tandy XENIX Computers

The X-Drive is a streaming-tape backup system for Tandy/Radio Shack computers that run XENIX versions 1.0 through 3.1. The drive backs up data at a rate of 2 megabytes per minute and uses standard ¼-inch tape cartridges that store up to 25 megabytes (formatted) of data.

Priced at $1495, the X-Drive comes with menu-driven software that includes formatting and diagnostic utilities. The drive connects to the computer's standard floppy-disk interface and works with the Model II, 12, 16, and 6000 computers. Contact Radio Ranch Inc., Dept. 16., 11658 West Judson Rd., Polo, IL 61064, (815) 946-2371.
Inquiry 572.

Two Printers from C. Itoh

The C-310 dot-matrix and D10-40 daisy-wheel printers have been announced by C. Itoh. The C-310 model prints at speeds of up to 300 characters per second in draft mode. The printer also produces near-letter-quality text at 50 cps and 28 cps. Other features of the 80-column printer are a parallel port, graphics resolution of 240 by 144 dots, resident character fonts, and a semiautomatic paper loader for handling fanfold, roll, and single-sheet paper. Suggested retail price for the C-310 is $599.

The 136-column D10-40 daisy-wheel printer operates at a speed of 40 cps. Its features include three character pitches, Diablo 630 compatibility, a parallel and a serial interface, and an 8K-byte buffer. Automatic sheet and tractor feed are optional. Suggested retail price for the D10-40 is $949. Contact C. Itoh Digital Products Inc., 19750 South Vermont Ave., Suite 220, Torrance, CA 90502, (213) 327-2110 or (800) 423-0300.
Inquiry 573.

(continued)

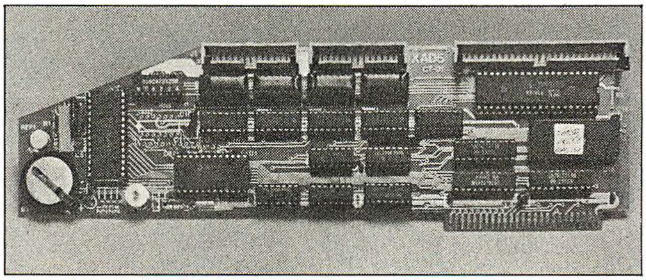
ADD-INS

Data Acquisition for Apple IIs

Xcalibur's XAD5 is a multifunction data-acquisition board for Apple II and compatible computers. The board includes 32 single-ended channels of 12-bit A/D conversion, either current loop or voltage input. The analog inputs may be configured for differential input with gain. XAD5 also provides 24 channels of digital I/O and a real-time clock/calendar with battery backup.

The board includes a feature called Autoscan, an interrupt-driven routine in ROM that automatically scans all channels and the real-time clock and then writes the values into the computer's RAM. Scanning is done at a rate of more than 100 channels per second.

XAD5 sells for $549, which includes a demonstration disk and manual. For more information, contact Xcalibur Computers Ltd., Spencer House, 3 Spencer Parade, Northampton, NN1 5AB England, telephone: 011-44-604-21051.
Inquiry 574.


Xcalibur's XAD5 *data-acquisition board.*

STD Bus and IEEE-488 Interface

Computer Dynamics' CDI-488 board provides an interface from an STD bus to the IEEE-488 GPIB. The board is intended for laboratory automation and applications using equipment with IEEE-488 protocols.

The CDI-488 can be either polled or interrupt driven. Other features include software-readable GPIB address switches and eight GPIB status indicators. The maximum data-transfer rate is 1 megabyte per second; 250K to 500K bytes per second is typical, according to the company.

The price for the CDI-488 is $300. Contact Computer Dynamics Inc., 105 South Main St., Greer, SC 29651, (803) 877-7471.
Inquiry 575.

More Memory for Ataris

Persistent RAM cartridges from Intra-Tech Computer Products are designed to expand the memory of Atari computers. Available in 16K- and 32K-byte versions, the cartridges use low-power RAM with backup power provided by a lithium cell.

Version I, the 16K-byte model, can be used in a 16K- or 8K-byte mode. Version II, the 32K-byte model, has two switch-selectable 16K-byte blocks. Each model has a switch that lets you change from read/write to read-only. Both can be used to make boot cartridges for most 15K-byte or smaller binary programs.

Version I costs $49.95, and Version II is $69.95. They run on the Atari 400, 800, 600XL, 800XL, 65XE, and 130XE computers with one disk drive. Contact Intra-Tech Computer Products, 2288 Portage Ave., Coquitlam, British Columbia V3K 2Z3, Canada, (604) 942-7049.
Inquiry 576.

EPROM Writer for IBM PCs

The Addonics EPROM Writer is an add-in card for IBM PCs and compatible computers that lets you program a wide variety of EPROM, EEPROM, and single-chip microcomputers. The EPROM Writer provides normal and high-speed programming modes and performs byte programming, memory fill, block move, RAM editing, check sum, and other functions.

The board comes with software drivers for computers running MS-DOS or Concurrent CP/M. Slight modification of the drivers enables you to program newly developed EPROMs.

The EPROM Writer sells for $450. For more information, contact Multitech Electronics Inc., 1008 Stewart Dr., Sunnyvale, CA 94086, (408) 773-8400.
Inquiry 577.

MaynStream Tape Drive

The MaynStream PCi 20 from Maynard Electronics is an internal streaming-tape backup system for the IBM PC and compatibles. It can back up a 10-megabyte drive file by file in 3 minutes and uses ⅛-inch data cassettes, which hold up to 20 megabytes of data each.

The MaynStream drive performs read-after-write checks to ensure the accuracy of backed-up data. It also has file-splitting capability, which lets you continue backup on a new cassette when the other is full.

The PCi 20 costs $1299 and comes with a controller card or module, one 20-megabyte cassette, software, and a manual. Contact Maynard Electronics, 460 East Semoran Blvd., Casselberry, FL 32707, (305) 331-6402.
Inquiry 578.

No-Wait-State Memory for the IBM PC AT

The Cheetah Card is a 2.5-megabyte expansion board with no-wait-state memory for the IBM PC AT. The board uses 100-nanosecond memory that, the company says, enables the AT to operate at higher speeds without the need to change its normal 6-MHz clock speed.

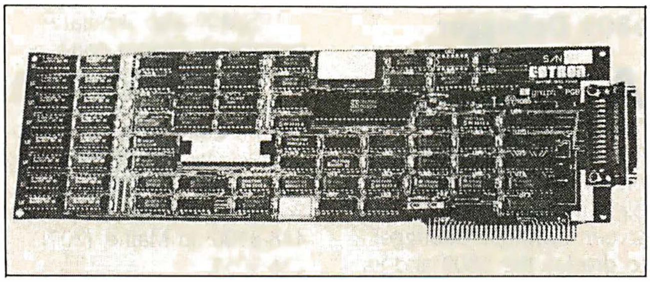
More than one Cheetah board can be installed. Each 512K-byte bank of memory is switch selectable within the IBM PC AT's 15-megabyte range. The 2.5-megabyte Cheetah Card costs $945, and the company claims the board is compatible with all AT software. Contact Cheetah International Inc., 107 Community Blvd., Suite 5, Longview, TX 75606, (800) 243-3824; in Texas, (214) 757-3001.
Inquiry 579.

ADD-INS

Faster High-Resolution Graphics

The EOgraph is an add-in board for IBM PCs and compatibles that's designed to speed up printing of high-resolution graphics. The board performs vector-to-raster conversion, area fills, and font generation and has a large-capacity print spooler to optimize throughput.

The board can be configured to drive monochrome and color dot-matrix printers and works with Lotus's 1-2-3, AutoCAD, and similar software. It can do multipage plots on fanfold paper and accepts graphics files from software that supports the Houston Instruments DMP-29 or DMP-41 plotter format.



Eotron's EOgraph graphics board.

Suggested list price is $495 for the 128K-byte version and $595 for the 512K-byte version. For more information, contact Eotron Corp., 121 Westpark Rd., Dayton, OH 45459, (513) 439-5158.

Inquiry **580.**

Practical Modem 1200

The Practical Modem 1200 is an internal 1200-bps modem for the IBM PC, XT, AT, and compatible computers. The modem is Hayes-compatible and meets Bell 212A and 103 standards. It offers auto-dial and auto-answer capabilities, full- and half-duplex operation, and pulse or Touch-Tone dialing.

The 4- by 5½-inch card fits into either a long or short expansion slot in the computer. The modem is bundled with communications software, including the Practical Terminal Package, which supports the XMODEM protocol, and Pop-Up Telecomm, a complete communications program from Popular Programs.

Suggested retail price for the modem is $199. For further details, contact Practical Peripherals Inc., 31245 La Baya Dr., Westlake Village, CA 91362, (818) 991-8200.

Inquiry **581.**

SOFTWARE • PROGRAMMING LANGUAGES AND AIDS

C Cross-Compiler

Microtec's High C is a C cross-compiler for producing embedded applications for Intel 8086 microprocessors. High C contains an ANSI-standard compiler, run-time libraries for producing an executable program, a set of source-code header files for accessing a library of standard run-time utilities, and a cross-reference feature that works on several program modules at once. A set of UNIX-like utilities is also included.

Features of the C compiler include nested functions with up-level references, a set of memory models, three integer ranges, and three IEEE real precisions. The compiler also provides common subexpression elimination, retention and reuse of register contents, dead-code elimination, and other functions.

High C is bundled with Microtec's ASM186L cross-assembler, linker/loader, object module librarian, and Microtec-format run-time libraries for embedded applications. The complete package costs $1550 and runs on the IBM PC and compatibles. Contact Microtec Research, 3930 Freedom Circle, Santa Clara, CA 95054, (800) 551-5554; in California, (408) 733-2919.

Inquiry **582.**

Beginner's Pascal

Alice: The Personal Pascal, from Software Channels, is designed for beginning Pascal programmers. The program is based on a syntax-directed editor that catches syntax and other types of errors when you type them in. The package provides templates that let you build and edit Pascal programs by filling in the blanks and offers more than 500 screens of on-line help. Alice's Pascal interpreter lets you view programs on screen while you run and debug them.

Programs you write with Alice can be compiled with other Pascal compilers. The program runs on the IBM PC, XT, AT, and compatible computers and costs $95. Contact Software Channels Inc., 4 Kingwood Place, Kingwood, TX 77339, (713) 359-1024.

Inquiry **583.**

GCLISP Developer

GCLISP 286 Developer from Gold Hill Computers is a LISP development package for the IBM PC AT and compatible computers. The package includes an interpreter and compiler, editor, tutorial, and on-line help system. It supports lexical scoping, packages, and transcendental functions and runs in the 80286's protected mode.

Priced at $1995, the GCLISP 286 Developer comes with the second edition of *LISP* by Patrick H. Winston and Berthold K. Horn, the *Common LISP Reference Manual* by Guy Steele, and a developer's manual. It requires a PC AT with at least 2 megabytes of memory, PC-DOS 3.0 or higher, one double-sided double-density or quad-density disk drive, and a hard disk. The company recommends 3 megabytes of memory, a Mouse Systems mouse, an enhanced graphics adapter, and color monitor.

Contact Gold Hill Computers Inc., 163 Harvard Ave., Cambridge, MA 02139, (617) 492-2071.

Inquiry **584.**

EPROM Programming

The PROMDisk program is aimed at program-

(continued)

SOFTWARE • PROGRAMMING LANGUAGES AND AIDS

mers developing code for EPROM-based IBM PC-compatible systems. The program lets you create an image of any file, including MS-DOS, which you can then load into EPROM. When the EPROM-based system is booted up, the file is copied from EPROM into RAM for execution. This system enables you to put MS-DOS in EPROM to support function calls made by compilers such as C, Turbo Pascal, and BASIC.

The program can create one to four RAM drives in EPROM, usually 16K to 32K bytes in size. PROMDisk costs $1995. For more information, contact I-Bus Systems, 9235 Chesapeake Dr., San Diego, CA 92123, (619) 569-0646.
Inquiry 585.

6809 Debugger

Avocet Systems' AVSIM09 is designed for debugging object code for a 6809 microprocessor on an IBM PC or compatible. The program uses a full-screen symbolic debugger to display the 6809 and its components, including registers, flags, programs, and memory.

The program has standard symbolic debugger features such as memory and register manipulation, code entry and display in assembly language, breakpoint setting, and single-stepping by instructions or by subroutines. An undo command lets you back up through recently executed instructions to determine where problems occurred.

AVSIM09 also simulates peripheral devices connected to the 6809 and can handle interrupts and I/O. The program sells for $299. Contact Avocet Systems Inc., 120 Union St., POB 490, Rockport, ME 04856, (800) 448-8500; in Maine, (207) 236-9055.
Inquiry 586.

Library of C Functions

CSL (C Scientific Library) is a collection of scientific functions for the C programming language. The collection is divided into several sublibraries. One group contains advanced algorithms for a variety of applications, including matrix decomposition and factorization. Another group offers single- and multistep methods for solving systems of differential equations of any order.

Other groups contain functions for time-valued transactions, graphics and data conditioning, complex discrete and fast Fourier transforms, real and complex polynomials, random numbers, least squares, regression, and probabilities.

CSL runs on a Zenith Z-100 or IBM PC or close compatible, with an 8087 coprocessor, Computer Innovations' C compiler, and MS-DOS version 2.0 or later. The program costs $245. For more information, contact Eigenware Technologies, 13090 La Vista Dr., Saratoga, CA 95070, (408) 867-1184.
Inquiry 587.

SOFTWARE • SCIENTIFIC AND ENGINEERING

Utility for Digitizing Tablets

Visual Numerics' Vishnu is a utility program for use with digitizing tablets that reduces graphical data to numeric tabular form. You place a graph, chart, map, blueprint, or other types of graphics on the tablet. By pointing with the digitizing stylus or puck, you can perform numerical differentiation, integration, and line integration to yield coordinates, angles, areas, and distances. By saving the data in an ASCII file, you can transfer it to spreadsheet and database programs or analyze it with FORTRAN, BASIC, or Pascal programs.

Vishnu supports Hitachi, Scriptel, GTCO, and compatible digitizing tables ranging in size from 11 by 11 to 36 by 48 inches. The program runs on the IBM PC, XT, AT, and compatibles and costs $250. Contact Visual Numerics Inc., POB 1726, Novato, CA 94948, (415) 892-2713.
Inquiry 588.

Schematics for AutoCAD

Icebox is a shape librarian for engineers who want to create schematics with AutoCAD. The program has a design and shape library for integrated circuits, as well as an editor for creating and editing IC shapes. It also includes a set of commonly used symbols such as ground, capacitors, and transistors.

The program comes with a predefined TTL library. Predefined Micro (Motorola/Intel) and Memory libraries are also available.

Icebox sells for $295; additional libraries cost $50 each. The program runs on the IBM PC and compatibles and on CP/M-based computers. Contact International Microsystems Inc., 11554 C Ave., Auburn, CA 95603, (800) 325-6028; in California, (916) 885-7262.
Inquiry 589.

Circuit-Analysis Software

Bloom Associates has released EDAC Inc.'s set of circuit-analysis programs that model control loops of four common switching regulators. The series of programs includes EDAC1-Buck (for buck regulators), EDAC2-TBuck (for transformer-coupled buck regulators), EDAC3-Flyback (for flyback regulators), and EDAC4-Boost (for boost regulators).

Each program displays a standard circuit model for its specific regulator. You fill in the component values on the schematic and can edit the values as needed. The program finds the DC operating point and determines if the operating mode is continuous or discontinuous. It then plots open- and closed-loop transfer functions, while accounting for the inductor current operating mode. You can print out the completed schematic.

The programs run on the IBM PC, XT, AT, and compatibles with 256K bytes of RAM, a graphics card, and a 360K-byte floppy-disk drive. Each program costs $295; a set of all four costs $995. Contact Bloom Associates Inc., 115 Duran Dr., San Rafael, CA 94903, (415) 492-8443.
Inquiry 590.

Ready-to-Run Software

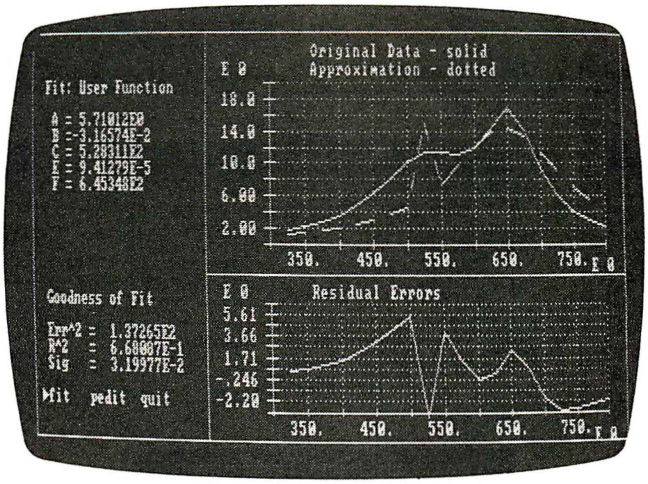
Asystant Ready-to-Run Scientific Software from Macmillan Software is a

SOFTWARE • SCIENTIFIC AND ENGINEERING

menu-driven program for advanced scientific applications. The package includes data-reduction, analysis, and presentation graphics-capabilities. A second version of the program, called Asystant+, can also perform data-acquisition functions.

Asystant's data-reduction features include fast Fourier transform, smoothing, integration and differentiation, and data set averaging. It can perform such data-analysis functions as curve fitting with automatic display of raw data, fitted curve, and residuals; statistics; differential equations; matrix operations; and polynomial operations.

The program also supports high-resolution color graphics and includes a variety of graphics features. Among these are line, scatter, polar, and log and semilog plots; axonometric and contour plotting; labeling; and plotter support.



Macmillan Software's Asystant scientific package.

Asystant+ offers the same capabilities as Asystant, along with data-acquisition functions. The company says that these functions simulate traditional laboratory instruments such as strip-chart recorders, transient recorders, and XY recorders. Features include real-time data display, automatic thermocouple linearization, cold junction compensation, a two-channel function generator, a graphics-based waveform editor, and operator control of A/D gain, data rate, digital output, and D/A range in offset.

Both programs run on IBM PC and compatible computers and require an 8087 coprocessor. Asystant sells for $495; Asystant+ is $895. For more information, contact Macmillan Software Co., 630 Third Ave., 8th Floor, New York, NY 10017, (800) 348-0033; in New York, (212) 702-3241.

Inquiry **591.**

SOFTWARE • BUSINESS AND OTHER

Grammar Checker

Sensible Software has followed up its Sensible Speller with Sensible Grammar, a grammar-checking program for Apple ProDOS. The package uses its library of more than 1000 commonly misused English phrases to identify bad writing. The company says the program will catch "pompous, informal, vague, wordy, repetitive, [or] sexist" prose. The software also traps punctuation, capitalization, and other typographical errors; shows errors in context; and suggests replacement wordings.

Sensible Grammar provides pull-down menus, scroll bars, and dialog boxes. It works with the AppleMouse but comes with a set of keyboard commands for mouseless Apple II users. The program runs on an Apple IIe or IIc with 80-column display and works with most word processors for Apple ProDOS. Retail price is $99.95. Contact Sensible Software Inc., 210 South Woodward, Suite 229, Birmingham, MI 48011, (313) 258-5566.

Inquiry **592.**

Disk, Diagnostics Utility

Sybil is Sophco's set of utilities that can recover accidentally formatted hard disks, unerase files, edit sectors, and modify file and directory attributes. The software can also handle diagnostics functions, such as testing system boards, memory, keyboard, ports, and video. Other programs in the package provide a print spooler, a RAM disk, and a graphics editor.

Sybil works on the IBM PC family and close compatibles. The price is $49.95. Contact Sophco Inc., POB 7430, Boulder, CO 80306, (800) 922-3001; in Colorado, (303) 444-1542.

Inquiry **593.**

WHERE DO NEW PRODUCT ITEMS COME FROM?

The new products listed in this section of BYTE *are chosen from the thousands of press releases, letters, and telephone calls we receive each month from manufacturers, distributors, designers, and readers. The basic criteria for selection for publication are: (a) does a product match our readers' interests? and (b) is it new or is it simply a reintroduction of an old item? Because of the volume of submissions we must sort through every month, the items we publish are based on vendors' statements and are not individually verified. If you want your product to be considered for publication (at no charge), send full information about it, including its price and an address and telephone number where a reader can get further information, to* New Products Editor, BYTE, 70 Main St., *Peterborough,* NH 03458.

DOS Directory Utilities

SuperPATH, a collection of RAM-resident DOS directory utilities for the IBM PC, lets you run any program from any directory, regardless of where it's stored; sort files by name, extension, date, time, or size (double sorts are allowed); build batch commands by merging filenames with other DOS commands; and choose from three display formats (five-column full-screen, long, or single-column short).

SuperPATH occupies 40K bytes of memory. It costs $39.95, is not copy-protected, and comes with a 30-day money-back guarantee. For more information, contact Martin Scot Development Corp., 4515 Purdue NE, Seattle, WA 98105, (206) 527-9605.

Inquiry **594.**

THE BUYER'S MART
A Directory of Products and Services

THE BUYER'S MART is a monthly advertising section which enables readers to easily locate suppliers by product category. As a unique feature, each BUYER'S MART ad includes a Reader Service number to assist interested readers in requesting information from participating advertisers.

RATES: 1x—$375 3x—$350 6x—$325
Prepayment must accompany each insertion.

AD FORMAT: Each ad will be designed and typeset by BYTE. Advertisers must furnish typewritten copy. Ads can include headline (23 characters maximum), descriptive text (250 characters maximum), plus company name, address and telephone number. Do not send logos or camera-ready artwork.

DEADLINE: Ad copy is due 2 months prior to issue date. For example: June issue closes on April 1. Send your copy and payment to THE BUYER'S MART, BYTE magazine, 70 Main Street, Peterborough, NH 03458. For more information call Karen Burgess at BYTE 603-924-9281.

THE BUYER'S MART

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SOFTWARE/EDUCATION

XENIX TUTOR AT LAST!!!
A 6 hr. training program on effective use of XENIX (UNIX) operating system. Ideal for non pros wanting grasp of multi-user/multi-tasking systems. Runs under PC-DOS on IBM PC, PC/XT, PC/AT & compatibles: Requires 128K + graphics board. **$350.** COD/VISA/MC/AE.
Hurricane Software
19415 S. Dixie Hwy., Miami, FL 33157
800-238-2389 FL 305-238-4800

Inquiry 699

SOFTWARE/GENERAL

Personal Tax Planner, $75.00 a lotus template for 1-2-3 or symphony One file includes the 13 most commonly used federal forms, which can be combined with one state file (all states with income tax & sales tax are available). All forms federal and state are interactive.
Micro-One-Write, $95.00 a checkbook accounting system This unique single entry system is fast, accurate, and very flexible. Unique features include windowing instant viewing of active account or department codes and running balance of money accounts. Export results to Lotus or dBase.
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Inquiry 721.

SOFTWARE/GRAPHICS

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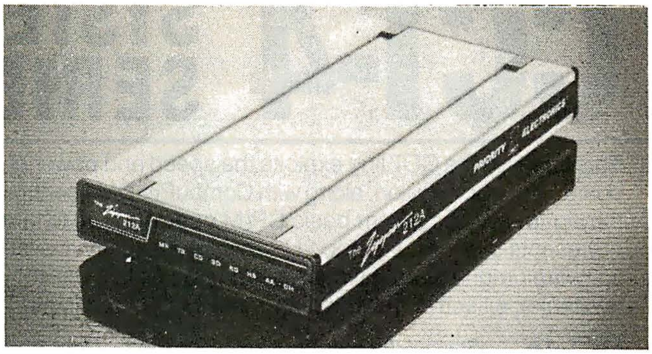
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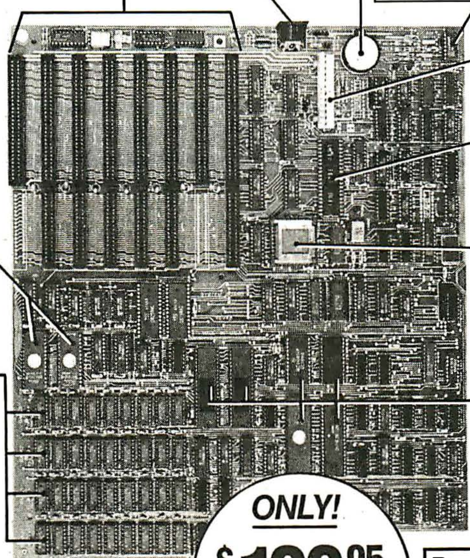
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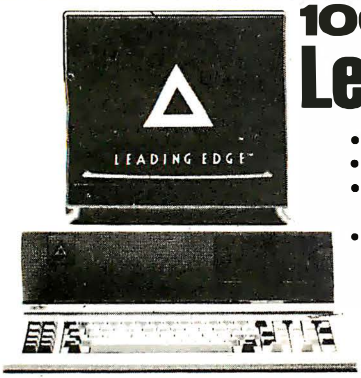
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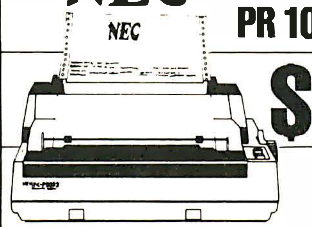
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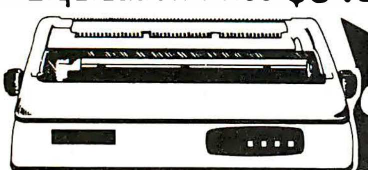
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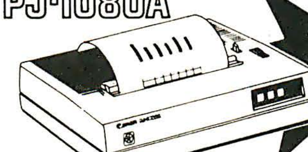
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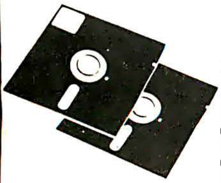


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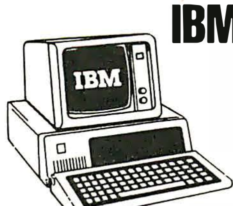
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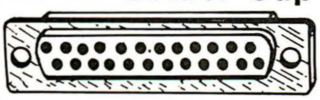
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74LS03	.14	74LS133	.46	74LS275	1.96
74LS04	.14	74LS136	.36	74LS279	.36
74LS05	.16	74LS137	.98	74LS280	1.18
74LS08	.16	74LS138	.36	74LS283	.56
74LS09	.16	74LS139	.36	74LS290	.86
74LS10	.14	74LS145	.86	74LS293	.76
74LS11	.18	74LS147	.86	74LS295	.66
74LS12	.18	74LS148	.86	74LS298	.66
74LS13	.36	74LS151	.36	74LS299	1.46
74LS14	.24	74LS153	.36	74LS323	2.46
74LS15	.24	74LS154	1.46	74LS324	1.68
74LS20	.16	74LS155	.46	74LS352	1.24
74LS21	.20	74LS156	.46	74LS353	1.18
74LS22	.20	74LS157	.34	74LS363	1.28
74LS26	.20	74LS158	.28	74LS364	1.88
74LS27	.20	74LS160	.28	74LS365	.36
74LS28	.24	74LS161	.36	74LS366	.36
74LS30	.16	74LS162	.46	74LS367	.36
74LS32	.16	74LS163	.36	74LS368	.36
74LS33	.26	74LS164	.46	74LS373	.76
74LS37	.24	74LS165	.64	74LS374	.76
74LS38	.24	74LS166	.86	74LS377	.76
74LS40	.16	74LS168	.94	74LS378	1.12
74LS42	.36	74LS169	.94	74LS385	1.84
74LS47	.56	74LS170	.84	74LS386	.42
74LS48	.66	74LS173	.46	74LS390	1.06
74LS49	.66	74LS174	.36	74LS393	.76
74LS51	.16	74LS175	.36	74LS395	1.06
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74LS63	.86	74LS190	.46	74LS447	.92
74LS73	.28	74LS191	.46	74LS490	1.46
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74LS75	.26	74LS193	.66	74LS640	.96
74LS76	.26	74LS194	.56	74LS645	.96
74LS78	.36	74LS195	.56	74LS668	1.46
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74LS93	.36	74LS243	.66	74LS685	2.86
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74LS109	.34	74LS248	.66	81LS95	1.36
74LS112	.26	74LS249	.96	81LS96	1.36
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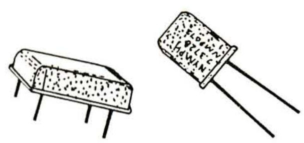
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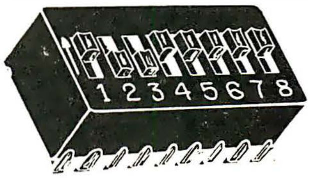
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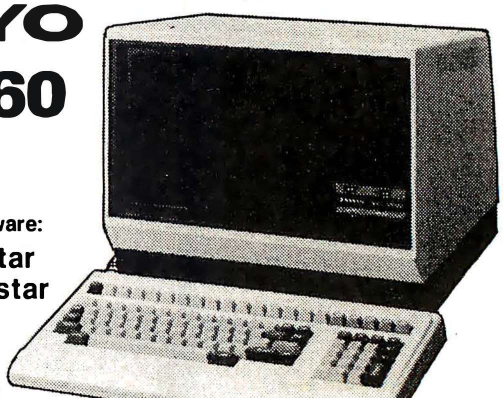
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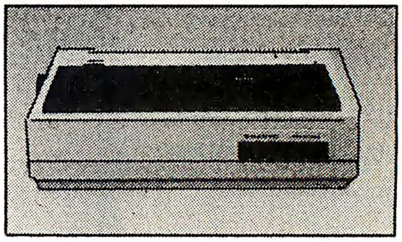


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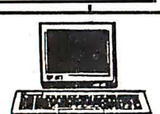
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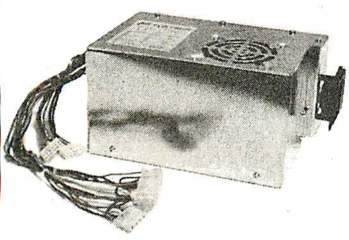
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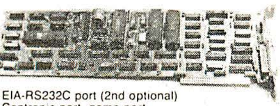
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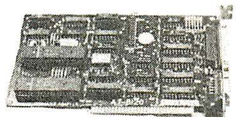
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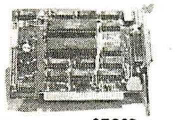
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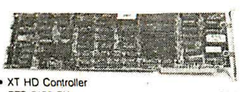
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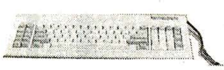
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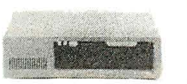
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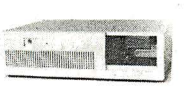
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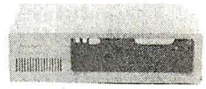


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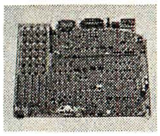
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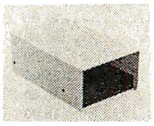


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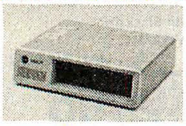
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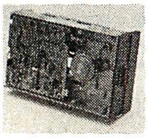


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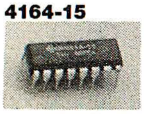
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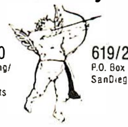
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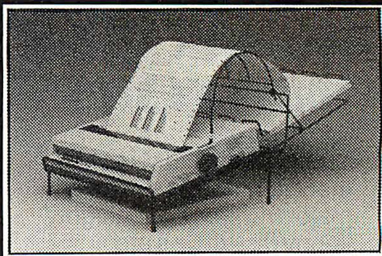
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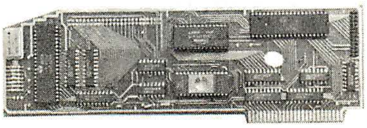
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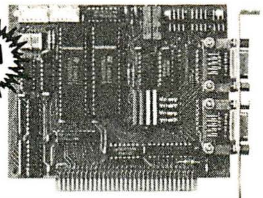
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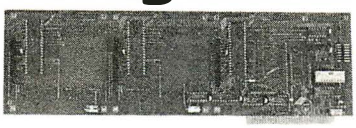
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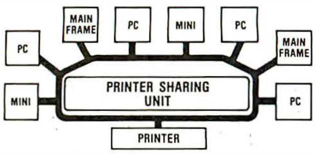


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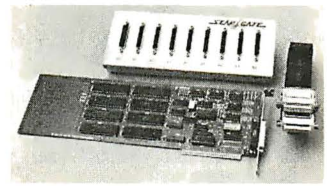
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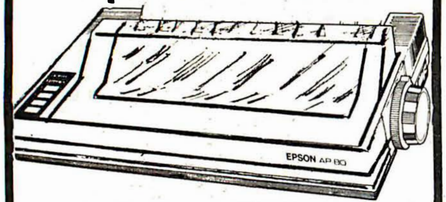
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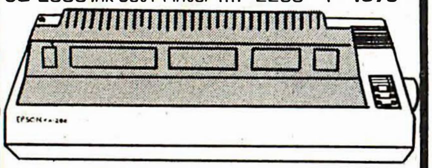


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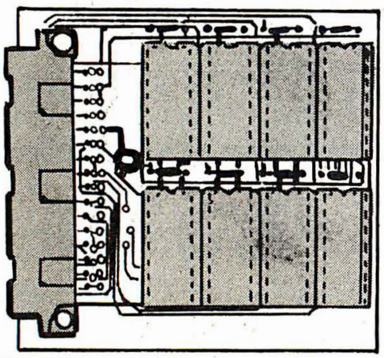


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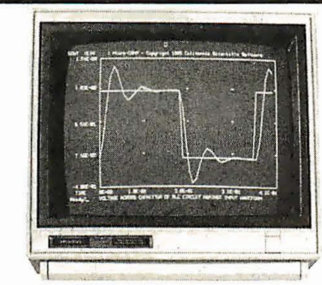
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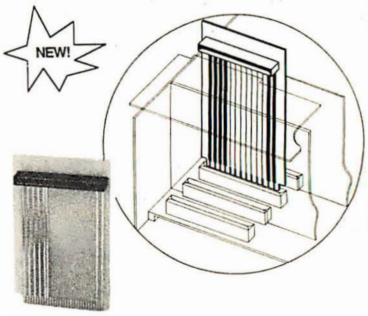


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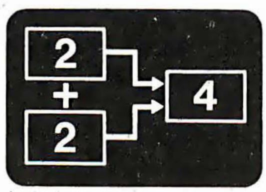
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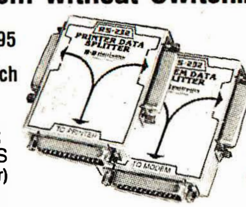
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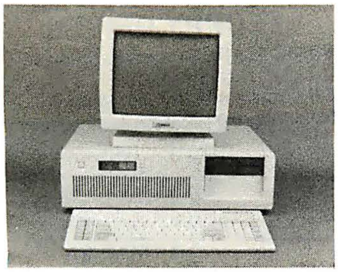


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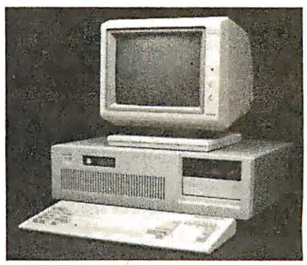
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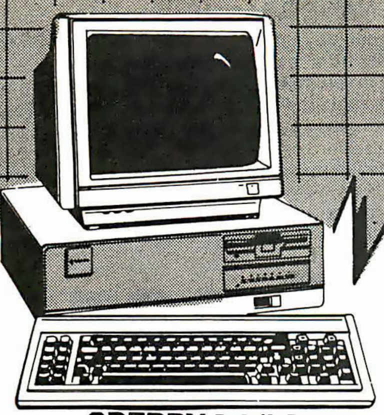
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- **ANCHOR VOLKSMODEM** 300 baud (cable opt.) $49
- **ANCHOR VOLKS** 6420 300 baud Commodore w/soft $59
- **ZOOM IIE** AP int. 300 baud AA/AD Hayes* comp. w/ soft $93
- **ANCHOR** Volksmodem 1200 (cable opt.) $164
- **SmarTEAM** 103/212A 1200/300 baud external AA/AD. Hayes*(AT) compatible. 2 year warranty. $178
- **ANCHOR EXPRESSi** 1200/300 baud PC internal, AA/AD Hayes*(AT) compatible $188
- **NOVATION SMARTCAT +** 1200/300 baud, int. or ext AA/AD. Hayes*(AT) comp. w/MITE* software $299
- **HAYES 1200B** w/ Smartcom II $333
- **ANCHOR LIGHTNING 24** 2400/1200/300 baud external Hayes*(AT) comp. Built-in speaker $338
- **NOVATION 2400** Professional w/o software $496
- **NOVATION 2400** with MS-DOS or Macintosh software $547
- **HAYES 2400** $568

MONITORS

- **AMDEK 310A** 12" Amber $143
- **AMDEK 600** $399
- **PRINCETON MAX**—12 Amber $166
- **PRINCETON HX**—12E RGB $544
- **TAXAN 122** monochrome $137
- **TAXAN 620** $392
- **TATUNG DM12VL** 12" green composite 1000 line res $118
- **TATUNG 1222A** 12" Amber TTL 1000 line res $118
- **TATUNG 1360** 13" Hi-Res RGB 640 X 200 .... $367

GUARANTEED AVAILABILITY!

Any item you order will be shipped within Two working days or you will be given a firm ship date when you order! If for any reason we cannot ship by the date you are given, we will deduct 5% from the price of the products shipped late and credit your order accordingly.**

COMPONENTS

Quality mfg. from companies like FUJITSU, HITACHI, OKI, NEC, SAMSUNG and TOSHIBA

- **256K DRAMS** Set of 9-150ns $26.46
- **64K DRAMS** Set of 9-150ns $8.91
- **128K DRAMS** price each $3.50
- **8087-3** $110.00
- **8087-2** $135.00
- **80287** $179.00
- **Y20-5MHz** $11.00
- **Y20-8MHz** $13.00
- **Y30** replaces 8086 .... $16.00
- **8086** $11.00
- **8088** $11.00
- **27128** $2.90
- **27256** $4.80
- **2764** $2.98

PERSYST STRETCH 2 MEGABYTE PC EXPANSION BOARD

Bank switched memory board supporting the LOTUS™, Ashton-Tate™ expanded memory spec. With Print Spool and RAM Disk software. Uses 256K chips.

0-K	1-Mb	2-Mb
$188	$292	$388

FUJI DS/DD Bulk In White Box

With sleeves, labels and s/p tabs. Priced per box of 10

1-19	20-99	100-499	500-999	1000 +
9.75	9.00	8.40	7.90	7.50

FUJI DS/DD Bulk w/o box, sleeves, labels or w/p tabs

Price each, in increments of 20 only, poly bagged

60-180	200-480	500-980	1000-4980	5K +
.85	.77	.72	.67	.63

****IF YOU DON'T SEE IT, CALL!**

We have virtually any product available at the best pricing. Space limits us to only a fraction of what we sell. Call us for a quote and delivery information. If we don't have it, we'll try to get it for you! All items priced and in stock at time of ad placement and subject to vendor changes and prior sale at time of ad publication.

***THE FINE PRINT**

Excluding software. Prior return authorization required; all items returned must be in original condition with carton, packing and all manuals, etc., some returns may involve a restocking charge. We accept Cashier and Certified checks, Money Orders, personal and company checks (product shipped when check clears), VISA and MasterCard with no surcharge and American Express (4% surcharge). All products shipped UPS ground (freight FREE for orders over $150), unless specified otherwise. All normal manufacturer's warranties apply.

WORLDWIDE ACCESS

Inquiry 370

EVERYBODY HATES US, BUT OUR CUSTOMERS!

Super Disk™ Diskettes

Now...Diskettes you can swear by, not swear at.

Lucky for you, the diskette buyer, there are many diskette brands to choose from. Some brands are good, some not as good, and some you wouldn't think of trusting with even one byte of your valuable data. Sadly, some manufacturers have put their profit motive ahead of creating quality products. This has resulted in an abundance of low quality but rather expensive diskettes in the marketplace.

A NEW COMPANY WAS NEEDED AND STARTED

Fortunately, other people in the diskette industry recognized that making ultra-high quality diskettes required the *best* and newest manufacturing equipment as well as the best people to operate this equipment. Since most manufacturers seemed satisfied to give you only the everyday quality now available, an assemblage of quality conscious individuals decided to start a new company to give you a new and better diskette. They called this product the *Super Disk* diskette, and you're going to love them. Now you have a product you can swear by, not swear at.

HOW THEY MADE THE BEST DISKETTES EVEN BETTER

The management of *Super Disk* diskettes then hired all the top brains in the diskette industry to make the *Super Disk* product. Then these top bananas (sometimes called floppy freaks) created a new standard of diskette quality and reliability. To learn the "manufacturing secrets" of the top diskette makers, they've also hired the remaining "magnetic media moguls" from competitors around the world. Then all these world class, top-dollar engineers, physicists, research scientists and production experts (if they've missed you, send in your resume to *Super Disk*) were given one directive...to pool all their manufacturing know-how and create a new, better diskette.

HOW SUPER DISK DISKETTES ARE MANUFACTURED

The *Super Disk* crew then assembled the newest, totally quality monitored, automated production line in the industry. Since the manufacturing equipment at *Super Disk* is new, it's easy for *Super Disk* to consistently make better diskettes. You can always be assured of ultra-tight tolerances and superb dependability when you use *Super Disk* diskettes. If all this manufacturing mumbo-jumbo doesn't impress you, we're sure that at least one of these other benefits from using *Super Disk* diskettes will:

1. **TOTAL SURFACE TESTING** - For maximum reliability, and to lessen the likelihood of disk errors, all diskettes must be totally surface tested. At *Super Disk*, each diskette is 100% surface tested. *Super Disk* is so picky in their testing, they even test the tracks that are in between the regular tracks.
2. **COMPLETE LINE OF PRODUCTS** - For a diskette to be useful to you and your computer, it must be compatable physically. *Super Disk* has an entire line of 5¼-inch and 3½-inch diskettes for your computer.
3. **SPECIALLY LUBRICATED DISK** - *Super Disk* uses a special oxide lubricant which is added to the base media in the production of their diskettes. This gives you a better disk drive head to media contact and longer head and disk life.
4. **HIGH TEMPERATURE/LOW-MARRING JACKET** - A unique high temperature and low-marring vinyl jacket allows use of their product where other diskettes won't work. This special jacket is more rigid than other diskettes and helps eliminate dust on the jacket.
5. **REINFORCED HUB RINGS** - Standard on all 48 TPI *Super Disk* mini-disks, to strengthen the center hub hole. This increases the life of the disk to save you money and increase overall diskette reliability.
6. **DISK DURABILITY** - *Super Disk* diskettes will beat all industry standards for reliability since they will give you more than 75% of the original signal amplitude remaining even after an average (Weibul B-50) of 30 million passes. They are compatible with all industry specifications as established by ANSI, ECMA, ISO, IBM and JIS.
7. **CUSTOMER ORIENTED PACKAGING** - All *Super Disk* disks are packaged 10 disks to a carton and 10 cartons to a case. The economy bulk pack is packaged 100 disks to a case without envelopes or labels.
8. **LIFETIME WARRANTY** - If all else fails, remember, all disks made by *Super Disk* Inc., have a lifetime warranty. If any *Super Disk* diskette fails to meet factory specifications, *Super Disk* Inc. will replace them under the terms of the *Super Disk* warranty.
9. **SUPERB VALUE** - With Super Disk's automated production line, high-quality, error-free disks are yours without the high cost.

Order toll free 800-USA-DISK

NOW...NAME BRAND QUALITY AT SUPER CE PRICES

Now, you can buy Super Disk brand diskettes directly from Communications Electronics at prices less than "unbranded" generic diskettes. Your data is valuable, so why take chances using a diskette that could be so unreliable that the manufacturer refuses to put their name on it. To save you even more, we also offer Super Disk bulk product where 100 diskettes are packed in the same box without envelopes or labels. Since we save packaging costs, these savings are passed on to you. 5¼" diskette envelopes are also available from us. These super strong and tear resistant envelopes are only $10.00 per pack of 100. Use order # CV-5 for a 100 pack of 5¼" diskette envelopes.

39¢ per disk Quantity One

Our diskettes are packed 10 disks to a carton and 10 cartons to a case. The economy bulk pack is packaged 100 disks to a case without envelopes or labels. For best value, you should order in increments of 100 diskettes. Almost all diskettes are immediately available from Super Disk. With our efficient warehouse facilities, your order is normally shipped in less than a day.

SAVE ON SUPER DISK™ DISKETTES Product Description	Part #	Super Disk price per disc ($)
5¼" SSSD Soft Sector w/Hub Ring	6431-FA	0.64
5¼" Same as above, but bulk pack w/o envelope	6437-FA	0.39
5¼" SSDD Soft Sector w/Hub Ring	6481-FA	0.68
5¼" Same as above, but bulk pack w/o envelope	6487-FA	0.43
5¼" DSDD Soft Sector w/Hub Ring	6491-FA	0.74
5¼" Same as above, but bulk pack w/o envelope	6497-FA	0.49
5¼" DSQD Soft Sector (96 TPI)	6501-FA	1.09
5¼" Same as above, but bulk pack w/o envelope	6507-FA	0.84
5¼" DSHD for IBM PC/AT - bulk pack	6667-FA	2.07
3½" SSDD (135 TPI) - bulk pack	6317-FA	1.67
3½" DSDD (135 TPI) - bulk pack	6327-FA	1.99

SSSD = Single Sided Single Density; SSDD = Single Sided Double Density; DSDD = Double Sided Double Density; DSQD = Double Sided Quad Density; DSHD = Double Sided High Density; TPI = Tracks per inch.

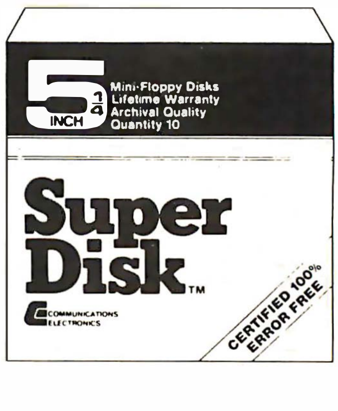
BUY YOUR DISKETTES FROM CE WITH CONFIDENCE

To get the fastest delivery of your diskettes, phone your order directly to our order desk and charge it to your credit card. Written purchase orders are accepted from approved government agencies and most well rated firms at a 10% surcharge for net 10 billing. For maximum savings, your order should be prepaid. All sales are subject to availability, acceptance and verification. All sales are final. All prices are in U.S. dollars. Prices, terms and specifications are subject to change without notice. Out of stock items may be placed on backorder or substituted for equivalent product unless we are instructed differently. A $5.00 additional handling fee will be charged for all orders with a merchandise total under $50.00. All shipments are F.O.B. CE warehouse in Ann Arbor, Michigan. No COD's. Non-certified checks require bank clearance. Michigan residents add 4% sales tax or supply your tax ID number and reason for tax exemption.

For **shipping charges** add $6.00 per 100 diskettes and/or any fraction of 100 5¼-inch or 3½-inch diskettes for U.P.S. ground shipping and handling in the continental U.S. For 1,000 or more disks shipped to the continental U.S., shipping charges are $4.00 per hundred diskettes. UPS 2nd day air rates are *three* times continental U.S. rates. For Canada, Puerto Rico, Hawaii, Alaska, or APO/FPO delivery, shipping is *three* times the continental U.S. rate.

Mail orders to: Communications Electronics Inc., Box 1045, Ann Arbor, Michigan 48106-1045 U.S.A. If you have a Visa or Master Card, you may call and place a credit card order. Order toll-free in the U.S. Dial 800-USA-DISK. In Canada, order toll-free by calling 800-CA1-DISK. If you are outside the U.S. or in Michigan dial 313-973-8888. Telex anytime 810-223-2422. Order your Super Disk diskettes now.

 Ad #040186-FA



Now 39¢ a disk

Inquiry 69

The Greatest buy on BASF Qualimetric Diskettes!

.79 Ea. Qty. 50 — 5.25"SSDD
.90 Ea. Qty. 50 — 5.25"DSDD

Packaged in boxes of 10 with Tyvec sleeves, user ID labels and write-protect tabs.

LIFTEIME WARRANTY!

	Qty. 20-40:	Qty. 50+:
5.25"SSDD(P/N3406)	.81	.79
5.25"DSDD(P/N3407)	.92	.90
5.25"SSDD-96TPI(P/N3404)	.92	.90
5.25"DSDD-96TPI(P/N3405)	1.03	1.01
5.25"DSDD-HD(P/N3403)	2.07	2.04
3.50"SSDD-135TPI(P/N3402)	1.85	1.82
3.50"DSDD-135TPI(P/N3412)	2.41	2.37

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DISK WORLD!

KODAK DISKETTES: Discover the future today!

.92 Ea. Qty. 100 — 5.25"SSDD
1.13 Ea. Qty. 100 — 5.25"DSDD

LIFETIME WARRANTY!

	Qty. 20-40:	Qty. 50:
5.25"SSDD(P/N4200)	1.00	1.00
5.25"DSDD(P/N4201)	1.23	1.21
5.25"SSDD-96TPI	N/A	N/A
5.25"DSDD-96TPI	N/A	N/A
5.25"DSDD-HD(P/N4202)	2.35	2.31
3.50"SSDD-135TPI(P/N4206)	1.87	1.84
3.50"DSDD-135TPI(P/N4207)	2.46	2.42

BULK 5.25" DISKETTES!
(Packaged in boxes of 100 with Tyvec sleeves, user ID labels and write-protect tabs.)

5.25"SSDD(P/N4203)	.92
5.25DSDD(P/N4204)	1.13

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3M Diskettes at the lowest prices ever!

.87 EA. <- 5.25"SSDD(P/N1000) Qty.50+
5.25"DSDD(P/N1004)-> **1.22** EA. Qty.50+

LIFETIME WARRANTY!
Packed in boxes of 10 with User ID labels and write-protect labels.

	Qty. 20-40:	Qty. 50+:
5.25"SSDD(P/N1000)	.88	.87
5.25"DSDD(P/N1004)	1.25	1.22
5.25"SSDD-96TPI(P/N1008)	1.73	1.70
5.25"DSDD-96TPI(P/N1011)	2.17	2.13
5.25"DSDD-HD(P/N1040)	2.52	2.48
3.50"SSDD-135TPI(P/N1039)	1.73	1.70
3.50"DSDD-135TPI(P/N1046)	2.47	2.42
8.00"SSSD w/WP(P/N1020)	1.54	1.52
8.00"SSDD w/WP(P/N1025)	1.89	1.86
8.00"DSDD w/WP(P/N1030)	2.15	2.11

DATA CARTRIDGES:
(Sold 10 to a carton only.)
(Add $ 5.00 shipping charges for cartridges.)

DC1000(P/N1041)	12.62	12.40
DC300XLP(P/N1042)	19.38	19.04
DC600A(P/N1043)	20.61	20.25

DISK WORLD!

BASF Qualimetric Diskettes in Bulk.

.72 Ea. Qty.150 — 5.25"SSDD
.83 Ea. Qty.150 — 5.25"DSDD

Save a lot of money by buying **BASF QUALIMETRIC** diskettes in bulk. Packed in cartons of 150 diskettes with Tyvec sleeves, User ID labels and write-protect tabs. **LIFETIME WARRANTY!**

	Qty. 150+:
5.25"SSDD(P/N3408)	.72
5.25"DSDD(P/N3409)	.83
5.25"SSDD-96TPI	N/A
5.25"DSDD-96TPI	N/A
5.25"DSDD-HD(P/N3410)	1.73*
3.50"SSDD-135TPI(P/N3411)	1.51**
3.50"DSDD-135TPI(P/N3412)	2.05**

* Available in 250 piece cartons only.
**Available in 200 piece cartons only.

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DISK WORLD!

DISK WORLD! Ordering & Shipping Instructions

FOR FASTEST SERVICE, USE NO-COST MCI MAIL. Our address is DISKORDER. It's a FREE MCI MAIL letter. No charge to you. (Situation permitting, we'll ship these orders in 24 hours or less.)
SHIPPING: 5.25" & 3.50" DISKETTES-Add $ 3.00 per each 100 or fewer diskettes. **OTHER ITEMS:** Add shipping charges as shown in addition to other shipping charges. **PAYMENT:** VISA, MASTERCARD and Prepaid orders accepted. **COD ORDERS:** Add $ 5.00 special handling charge. **APO, FPO, AK, HI & PR ORDERS:** Include shipping charges as shown and additional 5% of total order amount to cover PAL and insurance. We ship only to United States addresses, except as shown above. **TAXES:** Illinois residents add 7% sales tax.

MINIMUM ORDER: $ 35.00

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Brand new ribbons, manufactured to Original Equipment Manufacturer's specifications, in housings. (Not re-inked or spools only.)

EPSON MX-70/80(P/N2500)
$ 2.70 ea. + .25 Shpng.
EPSON MX-100(P/N2501)
$ 4.08 ea. + .25 Shpng.
Okidata Micro83(P/N2502)
$ 1.37 ea. + .25 Shpng.
Okidata Micro84(P/N2505)
$ 2.98 ea. + .25 Shpng.

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DISK WORLD!

ATHANA DISKETTES The great unknown!

.60 Ea. Qty. 50 — 5.25"SSDD
.69 Ea. Qty. 50 — 5.25"DSDD

LIFETIME WARRANTY!

	Qty. 20-40:	Qty. 50+:
5.25"SSDD(P/N3700)	.62	.60
5.25"DSDD(P/N3701)	.70	.69
5.25"SSDD-96TPI(P/N3702)	.89	.88
5.25"DSDD-96TPI(P/N3703)	.94	.92
5.25"DSDD-HD(P/N3704)	1.81	1.79
3.50"SSDD-135TPI(P/N3705)	2.03	2.00
3.50"DSDD-135TPI(P/N3706)	2.76	2.73

You've used these diskettes hundreds of times as copy-protected originals on some of the most popular software packages. They're packed in polybags of 25 with Polymer-impregnated sleeves userID labels and reinforced hubs, write-protect tabs.

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Diskette Storage Cases

AMARAY MEDIA-MATE 50:
A revolution in disk storage.
Every once in a while someone takes the simple and makes it elegant. This unit holds 50 5.25" diskettes, has grooves for stacking, inside nipples to keep diskettes from slipping and several other features. We like it. (P/N3010)
$ 9.69 ea. + $ 2.00 Shpng.
DISK MINDER II:
Low-priced, but effective storage for 75 5.25" diskettes. Smoked plastic top, beige bottom with inside dividers. (P/N2850)
$ 6.49 ea. + $ 2.00 Shpng.
DISK MINDER 36:
As above, but holds 36 3.50" diskettes. (P/N2900)
$ 6.49 ea. + $ 2.00 Shpng.
DISK CADDIES:
The original flip-up holder for 10 5.25" diskettes. Beige (P/N2200) or Grey (P/N2201)
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DISK WORLD!

SUPER STAR® DISKETTES:

The ultimate value in magnetic media.

No one told us how phenomenally successful Super Star® diskettes would become.

The idea was simple. Very simple.

We would do the same thing that big companies like IBM® do in regard to creating a "brand name" diskette. That is we would go to major manufacturers, buy top-quality diskettes in massive quantities, give them our own name and sell them inexpensively.

A very simple idea ...that worked!

Now, tens of thousands of businesses, government agencies, schools and individuals have learned that you don't have to pay inflated "brand name" prices to get "brand name" quality.

Just buy Super Star® diskettes.

Quality ...without high price.

We ship almost a million Super Star® diskettes a month and get very few of them back.

Unlike others who offer a "house brand" or "generic" diskettes, Super Star® diskettes are top-of-the-line quality, exceeding ANSI and IBM standards by 50% or more.

They are not cosmetically flawed, duplicator product (where a failure rate of 20% or more is expected) or what we in the diskette industry refer to as "floor sweepings", a term which speaks for itself.

A lifetime warranty.

If you sense pride in our description of Super Star® diskettes, you've got it right.

After all, wouldn't you be proud if you found a way to deliver top-quality diskettes at about half the price of "brand names"?

When every bit counts, it's Super Star®!

Nearly a million Super Star® diskettes a month are being sold to some of the largest and most recognizable names in the nation. They love 'em, because they save money...and they are dependable.

So now is the time for you to re-discover Super Star® diskettes.

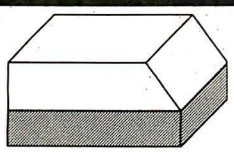
And we say "re-discover" for a reason.

You've already used Super Star!

Super Star® diskettes, as noted, are made by some of America's leading diskette manufacturers...and the odds are that you've already used them more than once as the copy-protected masters on some of the best known software programs around.

So, when you want the best...and the least expensive best...order Super Star®!

SUPER STAR SPECIAL!
Your choice of storage at $ 4.95!



Buy 50 Super Star® diske tes and get a storage case for only $ 4.95 (shipping included)!

These are durable plastic cases with dividers and are very nice units.

The 5.25" unit holds 50 diskettes and the 3.50" unit holds 40 diskettes.

5.25" Storage Case(P/N3100)..$ 4.95 ea.
3.50" Storage Case (P/N 3102).$ 4.95 ea.

What the world needs now is a complete line of high quality, inexpensive diskettes with a LIFETIME WARRANTY!

And DISK WORLD! has them!

Super Star 5.25" Diskettes

5.25" SSDD	(P/N 3800)	.55 ea.
5.25" DSDD	(P/N 3801)	.69 ea.
5.25" SSDD-96TPI	(P/N 3802)	.87 ea.
5.25" DSDD-96TPI	(P/N 3803)	.92 ea.
5.25" DSDD-HD	(P/N 3804)	$ 1.79 ea.

ORDER IN MULTIPLES OF 50 ONLY!

All Super Star 5.25" Diskettes are poly-bagged in lots of 25 with sleeves, write-protect tabs and user ID labels.
QUANTITY DISCOUNTS: 350-500 diskettes, deduct 3%. 500-700 diskettes, deduct 6%. 750-1,000 diskettes, deduct 9%. 1,000+ diskettes, deduct 12%.

Super Star 3.50" Diskettes

3.50" SSDD	(P/N 3805)	$ 1.73 ea.
3.50" DSDD	(P/N 3806)	$ 2.38 ea.

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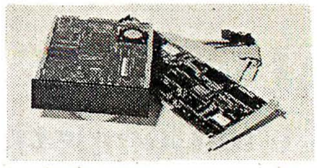
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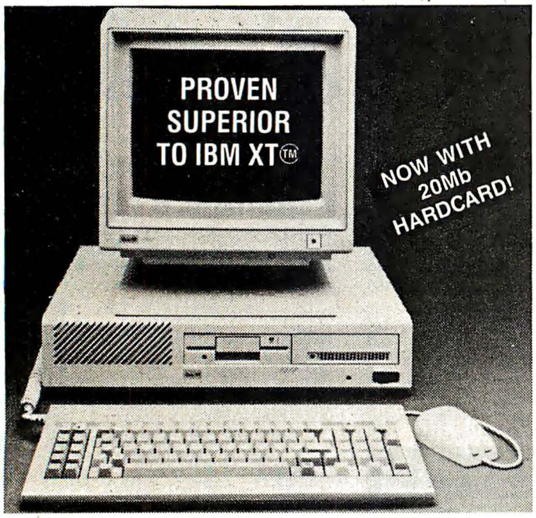
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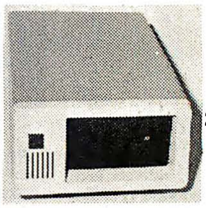
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2N2218A	.45	TIP30A	2/1.00
2N2219A	.45	TIP31A	2/1.25
2N2905	.45	TIP32A	2/1.25
2N2907	.25	1N4148	25/1.00
2N3055	.69	1N751	5/1.00
2N3565	4/1.00	1N4002	12/1.00
2N3638	4/1.00	1N4004	10/1.00
2N3772	1.69	MPQ2232	1.49

OPTO ISOLATORS

MCT-2	$ .59	4N33	$ .89
MCT-6	1.39	4N35	1.25
MCT-66	.55	4N37	1.25
MCA-255	1.69	4N38	.98
4N26	.65	TIL117	.79
4N27	.65	SPX33	.29
4N28	.69	4N25	5/1.00

LED LAMPS

	1-99	100
Jumbo Red	$ .09	$ .08
Jumbo Green	.17	.15
Jumbo Yellow	.17	.15
Mini Size Red	.10	.09
Mini Size Green	.19	.16
Mini Size Yellow	.19	.18

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24V@1A Open Frame OEM Model

Reg 34.95. ACP ONLY **$11.95**

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S-100 WW	4.75	4.10
44 Pin ST	2.75	2.60
44 Pin WW	4.75	4.25
72 Pin ST	6.50	6.10
72 Pin WW	7.25	8.95

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DB25S (Female	$3.10	$2.90
DB25P (Male)	2.40	2.29
Hood $1.25	Mtg H/W $ .99	
DE37S (Female)	$5.95	$5.75
DE37P (Male)	5.25	5.10
Hood $1.75	Mtg H/W $ .99	
DD50S (Female)	$8.95	$8.85
DD50P (Male)	6.00	5.75
Hood $3.25	Mtg H/W $ .99	

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IDC 36 Pin Female	9.49
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IDC CONNECTORS

IDC TYPE	ACP NO	NUMBER OF CONTACTS 10	20	26	34	40	50
Solder Header	IDHxxS	.79	1.20	1.65	2.10	2.40	3.00
Rt Angle Solder Header	IDHxxSR	.79	1.20	1.65	2.10	2.40	3.00
Ribbon Header Socket	IDSxx	.75	.95	1.35	1.50	1.85	2.10
Ribbon Header	IDMxx	—	5.25	5.95	6.75	7.25	8.25
Ribbon Edgecard	IDExx	1.70	2.15	2.50	2.60	3.70	3.95
Wirewrap Header	IDHxxW	1.80	2.90	3.75	4.25	4.95	6.50
Rt Angle W/W Header	IDHxxWR	1.99	3.10	4.10	4.20	4.60	7.15

NOTE: To order insert number of contacts in place of xx in ACP part number.

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6800	2.90	6821	2.90	6860	7.90
6802	7.75	6828	14.50	6875	6.75
6803	18.95	6840	12.75	6880	2.20
6809E	9.50	6845	11.95	38047	22.95

6500

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6502A	6.90	6507	9.75	6532	9.50
6502B	9.50	6520	4.25	6551	11.50

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8039	5.75	8216	1.95	8271	89.95
8060A	2.95	8224	2.20	8275	26.95
8085A	4.90	8226	1.95	8279	8.75
80C85A	9.95	8228	3.40	8282	8.25
8086	24.50	8237	13.75	8283	8.25
8087-2	129.95	8237-5	15.95	8284	5.50
8088	17.50	8238	4.25	8286	6.45
8089	88.95	8243	3.95	8287	6.45
8155	8.75	8250	10.50	8288	11.95
8156	6.75	8251	4.25	8289	44.95
8185	26.95	8251A	5.95	8292	12.95
8202	23.95	8253	6.75	8741	27.95
8203	37.95	8255	4.25	8748	24.50
8205	3.25	8255A	5.95	8749	24.50
8212	1.95	8257	5.75	8755A	34.95

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	2.5MHz	"A" 4.0MHz	"B" 6.0MHz
Z80-CPU	2.25	2.75	6.95
Z80-CTC	2.50	3.75	9.25
Z80-DART	7.50	8.50	17.95
Z80-DMA	8.00	8.95	17.95
Z80-PIO	2.95	3.50	9.50
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Z8030	$34.95	Z8001	$34.95	Z6132	$32.95
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1771	15.95	2791	32.95	8272	19.95
1791	22.75	2793	32.95	1691	6.95
1793	21.50	2795	32.95	2143	6.95
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2758 (5V)	5.50	2732A-2 (200nS)	8.95
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TMS2532	5.60	MCM68764 (450nS)	19.95
2732 (450nS)	2.95	MCM68766 (350nS)	21.95
2732 (250nS)	3.75	27126-3 (300nS)	9.50
2732 (200nS)	4.95	27128 (250nS)	15.95
CMOS EPROMS		27C32	$9.95
27C16	$7.95	27C64	10.95

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2101 (450nS)	$2.29	MK4118	$4.95
21L02 (450nS)	.99	TMM2016-2 (200nS)	4.10
2102-1 (450nS)	.79	TMM2016-15 (150n)	4.95
21L02-2 (250nS)	1.39	TMM2016-1 (100nS)	6.10
2111 (450nS)	2.75	HM6116P-4 (200nS)	4.75
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UPD410 (100nS)	3.75	93415 (50nS)	3.95
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4116N-2 (150nS)	1.25	41256-150 (150n)	2.75
4116N-3 (200nS)	1.10	41256-200 (200n)	2.75
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4006	.79	4031	3.25	4069	.28	4508	1.90
4007	.22	4032	2.15	4070	.35	4510	.79
4008	.95	4034	1.91	4071	.26	4511	.79
4009	.39	4035	.79	4072	.28	4512	.79
4010	.39	4037	1.95	4073	.28	4514	1.18
4011	.24	4040	.75	4075	.28	4515	1.79
4012	.24	4041	.75	4076	.75	4516	1.19
4013	.35	4042	.65	4077	.35	4518	.65
4014	.75	4043	.85	4078	.35	4520	.75
4015	.39	4044	.69	4081	.29	4555	.95
4016	.35	4046	.80	4082	.29	4556	.95
4017	.65	4047	.89	4085	.95	4566	1.35
4018	.79	4048	.99	4086	.95	80C95	1.50
4019	.39	4049	.35	4093	.45	80C97	.49
4020	.69	4050	.34	4094	2.95	MC14408	12.95
4021	.69	4051	.75	4098	1.90	MC14409	12.95
4022	.69	4052	.75	4099	1.85	MC14410	9.95
4023	.25	4053	.75	4501	.69	MC14411	11.95
4024	.59	4055	3.95	4502	.95	MC14412	12.95
4025	.25	4056	2.95	4503	.49	MC14419	4.95
4027	.45						

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LM301N	.35	LM709N	.55	LM3915	2.95
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LM305H	.95	LM710	.68	MC4024	3.75
LM306H	4.75	LM711	.75	MC4044	4.35
LM307N	.40	LM715	3.95	RC4131	3.75
LM308CN	.65	LM723N	.55	RC4136	1.19
LM310CN	1.65	LM723H	.75	RC4151	3.75
LM311CN	.62	LM733	.98	CA3023	2.75
LM312H	1.75	LM739	1.65	CA3039	1.25
LM318CN	1.45	LM741CN	.33	CA3046	1.25
LM318H	1.55	LM741H	.40	CA3059	2.85
LM319N	1.19	LM741N	.29	CA3060	2.65
LM320 (see VRs)		LM747	.65	CA3065	1.69
LM324N	.55	LM748	.55	CA3080	1.10
LM339N	.95	LM1014	1.15	CA3081	1.60
LM340 (see VRs)		LM1303	1.90	CA3082	1.60
LM348N	.95	LM1310	1.45	CA3083	1.55
LM358CN	.65	MC1330	1.65	CA3086	.80
LM359	1.75	MC1349	1.85	CA3089	2.95
LM360N	2.95	MC1350	1.15	CA3096	3.45
LM370N	4.95	MC1358	1.65	CA3130	1.29
LM373N	3.95	MC1372	6.75	CA3140	1.15
LM376N	3.75	LM1414	1.55	CA3146	1.79
LM377N	1.90	LM1558H	2.99	CA3160	1.49
LM380CN	.85	LM1800	2.35	LM13080	1.25
LM380N	1.05	LM1812	8.10	LM13600	1.45
LM381N	1.59	LM1830	3.40	LM13700	1.45
LM362N	1.35	LM1871	5.45	LF347	2.19
LM383N	1.95	LM1872	5.45	LF351	.60
LM384N	1.75	LM1877	3.20	LF353	.99
LM386N	.89	LM1889	1.90	LF355	1.10
LM387N	1.29	LM1896	1.70	LF356	1.10
LM389N	1.15	ULN2001	1.95	LF357	1.39
LM392N	.69	ULN2003	1.49	TL071CP	.79
LM723N	.48	XR2206	3.75	TL072CP	1.35
LM723H	.55	XR2207	2.90	TL074CN	1.90
NE531	2.85	XR2208	2.40	TL081CP	.59
NE555	.35	XR2211	3.75	TL084CN	1.90
NE556	.65	LM2877P	2.00	TL494	4.10
NE558	1.49	LM2878P	2.25	TL496	1.65
NE561	23.50	LM2900	.83	TL497	3.20
NE564	2.65	LM2901	.99	MC3423	1.49
LM565	.95	LM2903	.69	MC3453	4.95
LM568	1.45	LM2907	2.45	MC3456	1.29
LM567	.85	LM2917	2.85	MC3459	3.75
NE570	3.85	LM3900	.55	MC3469	5.25
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78M06C	.89	LM309K	1.25
78MG/79MG	1.49	LM317H/K	1.25/3.85
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7401	.18	7447	.65	74125	.42	74177	.69
7402	.18	7448	.68	74126	.44	74179	1.34
7403	.18	7450	.19	74128	.49	74180	.75
7404	.18	7451	.19	74132	.45	74181	1.75
7405	.23	7453	.19	74136	.75	74182	1.15
7406	.49	7454	.19	74141	.85	74184	2.25
7407	.49	7459	.25	74142	2.95	74185	2.25
7408	.24	7460	.37	74143	3.70	74190	.67
7409	.19	7470	.29	74144	2.95	74191	.67
7410	.19	7472	.29	74145	.59	74192	.67
7411	.24	7473	.33	74147	1.49	74193	.67
7412	.38	7474	.34	74148	1.19	74194	.67
7413	.34	7475	.38	74150	1.09	74195	.67
7414	.49	7476	.34	74151	.55	74196	.75
7416	.49	7479	4.60	74152	.67	74197	.86
7417	.49	7480	.89	74153	.53	74198	1.15
7420	.19	7482	.95	74154	1.19	74199	1.15
7421	.35	7483	.45	74155	.69	74221	1.19
7422	.45	7485	.55	74156	.59	74251	.75
7423	.58	7486	.35	74157	.59	74273	1.65
7425	.29	7489	1.95	74158	1.65	74276	1.89
7426	.29	7490	.35	74159	1.58	74279	.75
7427	.25	7491	.65	74160	.79	74283	1.40
7428	.55	7492	.45	74161	.69	74284	2.90
7430	.18	7493	.35	74162	.69	74285	2.90
7432	.29	7494	.85	74163	.69	74290	1.49
7437	.25	7495	.50	74164	.69	74298	1.49
7438	.29	7498	.69	74165	.69	74365	.55
7439	.58	7497	2.70	74166	.85	74366	.55
7440	.19	74100	1.50	74167	2.75	74367	.55
7441	.79	74107	.24	74170	1.25	74368	.55
7442	.45	74109	.37	74172	4.75	74390	1.45
7443	1.15	74118	1.45	74173	.69	74393	1.33
7444	1.15	74121	.29	74174	.69	74490	2.25
7445	.68	74122	.44	74175	.69		

74LS00

74LS00	$ .15	74LS113	$ .38	74LS247	$ .74
74LS01	.15	74LS114	.39	74LS248	.98
74LS02	.15	74LS122	.45	74LS249	.98
74LS03	.15	74LS123	.95	74LS251	.59
74LS04	.24	74LS124	2.75	74LS253	.59
74LS05	.25	74LS125	.49	74LS257	.59
74LS08	.27	74LS126	.49	74LS258	.59
74LS09	.28	74LS132	.59	74LS259	2.95
74LS10	.25	74LS136	.39	74LS260	.59
74LS11	.33	74LS138	.59	74LS261	2.49
74LS12	.33	74LS139	.59	74LS266	.55
74LS13	.39	74LS145	1.19	74LS273	1.45
74LS14	.59	74LS148	1.38	74LS275	3.29
74LS15	.33	74LS151	.55	74LS279	.59
74LS20	.26	74LS153	.55	74LS283	.68
74LS21	.29	74LS154	1.49	74LS290	.88
74LS22	.29	74LS155	.69	74LS293	.78
74LS26	.29	74LS156	.69	74LS295	.98
74LS27	.29	74LS157	.69	74LS298	.88
74LS28	.29	74LS158	.69	74LS324	1.75
74LS30	.25	74LS160	.69	74LS347	1.95
74LS32	.33	74LS161	.69	74LS348	1.95
74LS33	.53	74LS162	.69	74LS352	1.25
74LS37	.35	74LS163	.69	74LS353	1.25
74LS38	.39	74LS164	.69	74LS363	1.29
74LS40	.25	74LS165	.90	74LS365	.48
74LS42	.44	74LS166	1.90	74LS366	.48
74LS47	.74	74LS168	1.15	74LS367	.45
74LS48	.74	74LS169	1.15	74LS368	.45
74LS51	.25	74LS170	1.40	74LS373	1.39
74LS54	.29	74LS173	.67	74LS374	1.33
74LS55	.29	74LS174	.67	74LS375	.89
74LS73	.39	74LS175	.67	74LS377	1.38
74LS74	.34	74LS181	1.95	74LS385	1.95
74LS75	.39	74LS190	.85	74LS386	.45
74LS76	.39	74LS191	.85	74LS390	1.15
74LS78	.39	74LS192	.78	74LS393	1.15
74LS83	.59	74LS193	.78	74LS395	1.15
74LS85	.69	74LS194	.69	74LS399	1.47
74LS86	.39	74LS195	.69	74LS424	2.95
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74LS95	.75	74LS240	.95	81LS96	1.45
74LS96	.89	74LS242	.95	81LS97	1.45
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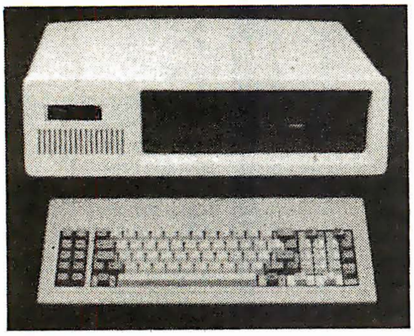
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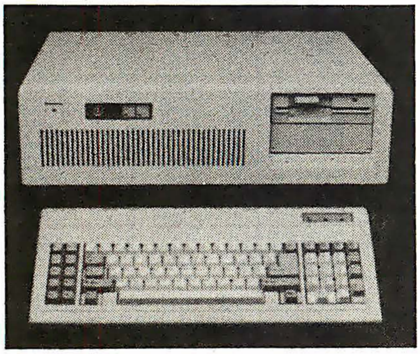
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OPTIONS FOR PROMODEM 1200 ARE:
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HAYES *SMART MODEM 2400* Universal **$659**
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Expands Model 4 from 64K to 128K

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NEC Model PC-8201A Expansion
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Intelligent 1200/300 Baud Modem with Real Time Clock/Calendar

The ProModem™ is a Bell 212A (1200/300) intelligent stand-alone modem • Hayes command set compatible plus an additional extended command set • Shown with alphanumeric display option. RS-232 Stand-Alone Unit:
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16K RAM CARD (Language Card)
For Apple II and II+*



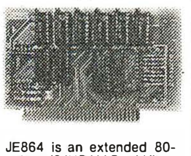
Expand from 48K-64K. Runs AppleSoft, DOS, CP/M and Pascal. (ARC-16K/MEM-1)
JE860 . . $39.95**

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For Apple II, II+ and *IIe**

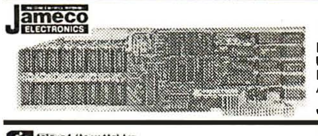


Capable of handling up to two drives. Recommended drives: ADD-514 or ADD-12. (ACC-1)
JE875. . . . $49.95

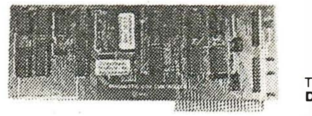
EXTENDED 80-COLUMN CARD
For Apple *IIe**



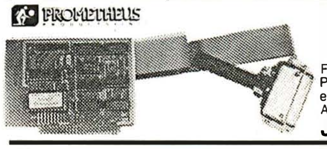
JE864 is an extended 80-column/64K RAM Card. Ultra-high resolution capability.
JE864. . . . $69.95



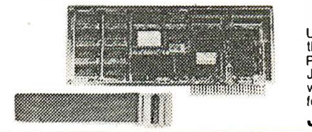
128K RAM CARD
For Apple II, II+ and *IIe**
Four key software programs are included: Utilities, Diagnostics, Demos, and RAM Disk Emulators for DOS 3.3, CP/M and Apple Pascal. Expand-A-RAM:
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PREVENTS CRASHES!
Test your RAM, ROM, CPU and Disk Drives. DRV-1/Applesurance II:
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PARALLEL PRINTER CARD
For Apple II, II+ and *IIe**
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*APPLE, APPLE II, II+ and *IIe* are registered trademarks of Apple Computers.
**When using CP/M, the JE860 and JE868 will only function with Version 2.20 or earlier: PASCAL (JE868) Version 1.1 or earlier.

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Power/Mate Corp. REGULATED POWER SUPPLY
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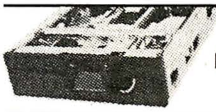
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• Input: 110V @ 60Hz • Output: +5VDC @ 15A, –5VDC @ 0.5A, +12VDC @ 4.2A, –12VDC @ 0.5A • Plug compatible connectors • Fits into IBM PC • Weight: 6 lbs.
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TM100-2	Tandon 5¼" DS Full-Height	$119.95

JMR 5¼" DISK DRIVE ENCLOSURES
Complete with power supply, switch, power cord, fuseholder and connectors.
DDE-1FH. $69.95
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DDE-2HH. $79.95
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HDDE-1FH. $199.95
Houses 1 Hard Disk Drive

UV-EPROM ERASER

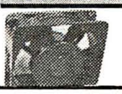


Erases all EPROMs. Erases up to 8 chips within 21 minutes (1 chip in 15 minutes). Maintains constant exposure distance of 1". Special conductive foam liner eliminates static build-up. Built-in safety lock to prevent UV exposure. Compact - 9.00"L x 3.70"W x 2.60"H. Complete with holding tray for 8 chips.
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30013	Zilog Data Book (85)	$14.95
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Howard Industries (4.68" sq., 60 cfm)
SU2C7. . . . . $9.95
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IBM Compatible Computer

$495



Eclipse
DATA PRODUCTS

- 256K Expandable to 640K on Motherboard
- Double Sided Double Density Disk Drive
- IBM Type Keyboard (with LED indicators)
- Floppy Controller Card
- Eight Expansion Slots
- 135 Watt Power Supply

The Eclipse 16 is an outstanding value in IBM Compatible Computers. After careful research and evaluation we found it to be the most reliable unit.

Our computer includes some of the newest features available, such as the 4.7MHz, multi-layer motherboard with 256K of RAM upgradable on board to 640K. A generous eight expansion slots and 135 Watt power supply give you ample room and power for add-on boards. The enclosure has an easy-access flip top lid making upgrades a breeze. And our floppy controller supports up to four drives, so as many as three additional drives can be used. Finally, each computer is configured and fully tested before sending it to you.

Satisfaction Guaranteed! We're really excited about this new unit, and so sure you will be too... that you may return the Eclipse 16 for a full credit towards an IBM PC if you are not completely satisfied.

OPTIONS

20MB Hard Drive w/Controller	$495	RGB Color Monitor	199
Additional Drive-Installed	99	TTL Monochrome Monitor	139
Irwin 10 Meg. Tape Back up	489	Microsoft Mouse	139
Upgrade from 256K to 640K RAM	79	Upgrade from Floppy Controller to Disk I/O 2 drive controller, clock/cal., software parallel, serial, and game ports	79
8087 Math Co Processor	119	1200 Baud Internal Modem w/Software	179
Color Graphics Card	79		
Monochrome Graphics Card	99		

XEROX $299

SUNRISE COMPUTER



The Xerox Sunrise 1810 is by far the best value we have ever seen in a micro computer. This is a self contained battery and AC operated portable. The Sunrise was originally prices at $2995. Xerox has since elected to drop the computer from their product list. California Digital has purchased all the remaining inventory and is making the unit available at a fraction of its original cost.

This portable features a built in 80 column liquid crystal display, 64K of memory along with both RF monitor and television outputs. The internal 300/1200 baud modem includes an auto dial telephone assembly. The units has both centronics parallel and a serial port programmable to 19,200 baud. The self contained micro cassette is capable of capturing data from the keyboard as well as doubling as an recorder for dictating messages.

An optional dual floppy disk drive module, pictured above, is available for only $219. Also available, for $59 is an 80 column printer that mounts in the drive module. The Sunrise features a CP/M operating system which allows the operator to use any CP/M program in Xerox 5¼" disk format and over 5000 CP/M programs available in public domain.

We have avalable a 15 minute tape on the Sunrise Computer. The tape is in VHS format and was produced by Xerox to promote the computer. California Digital is offering the promotional tape at $15. This will be applied towards purchase price of the Sunrise 1810 computer.

Eclipse 1200

1200 Baud Hayes Compatible

Your Choice $179



The Eclipse 1200 and 1200B (IBM internal) represent the best value we have ever offered in a fully Hayes Compatible 300/1200 baud modem. Both units include speaker, auto dial and data communication software. The external also features status indicators LED's. The internal includes an auxillary RS-232 serial port. California Digital is so confident of your complete satisfaction that we will allow the return of either Eclipse 1200 modem and apply the full credit towards the purchase price of any other modem.

1200 BAUD MODEMS

AVATEX 1200 $99



This 300/1200 baud modem matches the design specs of the Bell 212A, feature by feature, bringing you reliability, impeccable transmission and easy operation. Hayes Compatible, except for "S" register. Communication software included.

The AVATEX 1200, at $99, is a steal!

SMARTEAM 1200 $189



The Team 212A offers all the features of the Hayes Smart Modem 1200 for a fraction of the price. Now is your opportunity to purchase a 1200 baud modem at the price of a 300 baud modem.

SIGNALMAN 300 BAUD MARK VI $49



The Anchor Automation Mark VI is a 300 baud direct connect modem that plugs into any slot of your IBM/PC. This modem supports auto answer and auto dial capabilities. Other features include telephone number storage, send / receive text files, single key-stroke dialing along with many other functions provided on disk. The Mark VI was originally priced at over $300.

UltraLink 1200



The UltraLink is a 1200 baud HALF DUPLEX bell202 compatible internal modem card for the IBM/PC. This unit operates full duplex at 300 baud.
The UltraLink adds a voice/data demension to your PC. Manufacturers original suggested price on this modem is $795. California Digitals price is only $99.

$99

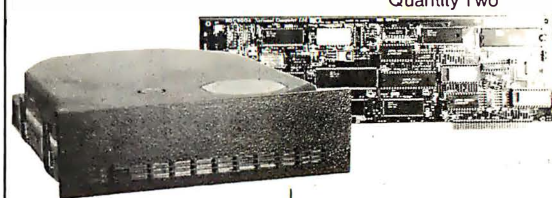
MODEMS

Eclipse 1200 100% Hayes, with status lamps.	ECP-1200	179.00
Eclipse 1200B internal with software	ECP-1200B	179.00
Hayes Smartmodem 2400 baud modem	HYS-2400	599.00
Fujitsu 2400/1200 baud auto everything.	FUJ-1935D	459.00
Team 1200 Hayes Compatible, 300/1200 baud.	TEM-SM1200	189.00
UltraLink 1200 data and voice on same line.	UTL-1200A	99.00
CTS 212AH 1200 baud, auto dial	CTS-212AH	219.00
Terminal software for CTS 212AH	CTS-212SFT	35.00
Prometheus 1200 super features	PRM-P1200	289.00
Prometheus 1200B internal PC	PRM-P1200B	279.00
Signalman Mark VI, 300 baud internal PC	SGL-MK6	49.00
Hayes Smart Modem 1200 baud, auto dial	HYS-212AD	369.00
Hayes 1200B for use with the IBM/PC, 1200 baud.	HYS-1200B	299.00
Hayes Smartmodem, 300 baud only, auto dial	HYS-103AD	199.00
Hayes Chronograph, time & date	HYS-CHR232	199.00

Seagate $359

20 MEGABYTE WINCHESTER HARD DISK DRIVE

Quantity Two



Five Inch Winchester Disk Drives

	each	two+
SEAGATE 225 20 Meg. ½ Ht.	389	359
SEAGATE 4026 26 M. 35mS.	859	829
SEAGATE 4051 51 M. 35mS.	1095	1059
FUJITSU 2242 55 M. 35mS.	1799	1729
FUJITSU 2243 86 M. 35mS.	2295	2219
ROOIME RO-202E 27 Meg.	759	729
ROOIME RO-203E 40 Meg.	995	959
ROOIME RO-204E 53 Meg.	1259	1195
CONTROL DATA 94155-86 M.	1829	1779
MAXTOR XT1140 140 Meg.	3379	3295
HONEYWELL 85M. 27 mS.	1795	1695
TOSHIBA MK5670 M. 30mS.	1789	1729
TANDON 502 10 Meg.	419	379

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DTC 5150BX	159
OMTI 5510 half card	189
ADAPTEC 2010A software install	189
WESTERN DIGITAL WD/1002	189

• SCSI/SASI Winchester Controllers •

XEBEC 1410A 5¼" foot print	239
OMTI 20L	119

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Switching power supply	49

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$429 Quantity Two

Single piece price $499. But if you have already purchased an F-10 printer from California Digital, we will honor the $429 price on the second printer.



The TEC F-10 Daisy Wheel printer is the perfect answer to a reasonablly priced 40 character word processing printer. While this printer is " extremely" similar to C.Itoh's F-10/40 Starwriter printer. Legal counsel for the C.Itoh Company have advised us that we should refrain from referring to the TEC printer as a Starwriter.

This 40 character per second printer auto installs with Wordstar and Perfect Writer. Features extensive built-in word processing functions that allow easy adaptability and reduced software complexity. Industry standard Centronics interface provides instant compatibility with all computers equiped with a parallel printer port. The TEC F-10 accepts paper up to 15 inches in width.

These printers were originally priced to sell at over $1400. Through a special arrangment California Digital has purchase these units from a major computer manufacturer and is offering these printers at a fraction of their original cost.

Options available include sheetfeeder, tractor feed, buffered memory and an assortment of printer cables for a variety of computers.

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Your Choice 48 or 96 TPI drive.
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TEAC FD55GF for IBM AT	189	179	175
SHUGART SA455 Half Height	119	109	105
SHUGART SA465 ½ Ht. 96TPI	125	119	109
TANDON 100-2 full height	129	125	119
MITSUBISHI 4851 halfheight	119	109	105
MITSUBISHI 4853 96/TPI½ Ht.	99	89	89
MITSUBISHI 4854 8" elec.	295	285	275
QUME 142 half height	99	89	89
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Uses a standard RS-232 serial port hookup to interface easily with your computer.

PLOTTER $219



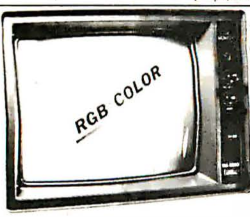
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The Comscriber I features programmable paper sizes up to 8½ by 120 inches, 6 inch per second plot speed and 0 004 step size Easy to implement Centronics interface allows the Comscriber I immediate use with the printer port of most personal computers

The Comscriber I is manufactured for Comrex by the Enter Computer Corporation. The plotter is marketed by Heath Kit and also sold under Enters own "Sweet P" Label. This is your opportunity to purchase a plotter which was originally priced at $795 for only $219

Also available is a support package which includes demonstration software, interface cable, a multicolor pen assortment and a variety of paper and transparency material.

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The NEC JC-1401D is a 13" medium/high resolution RGB monitor suitable for use with the Sanyo MBC-550/555 or the IBM/PC The monitor features a resolution of 400 dots by 240 lines. Colors available are Red, Green, Blue, Yellow, Cyan, Magenta, Black and White.
The NEC monitor carries the Litton-Monroe label and was originally scheduled for use in their "Office of the Future" equipment. A change in Monroe's marketing strategy has made these units excess inventory which were sold to California Digital We are offering these "new" RGB monitors at a fraction of their original cost Sanyo compatible NEC-1401/S; IBM/P/C Computer compatible NEC-1401/PC

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The Quick-Link 300 gives you an instant link to any dial up data base. Such as Dow Jones, Western Union or the Source. The Quick-Link has four user programmable log-on keys, allowing the operator, with only one key stroke, to dial the data base, log-in and give the password. All this information is permanently stored in non-volatile RAM.

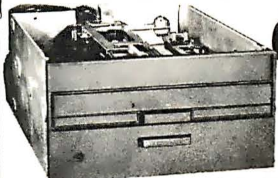
Features include video output to television or monitor, auto dial, auto-log, full sized keyboard, 300 baud modem and 1200 baud auxillary printer port. All this is available for only $59.

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Compatible with most Radio Shack Color Computer software. The world famous Dragon computer is now available in the United States. Manufactured by the Tano Corp. under license of the British Broadcasting Company.
The Dragon comes complete with 64K Byte of memory, serial modem port along with a Centronics printer interface. This unique microcomputer features Motorola's advanced 6809E microprocessor and comes standard with Micro-soft Color Basic, data base manager, and a complete word processing package. The computer outputs color composite video along with R.F. video that allows the unit to be used in conjunction with any color television.
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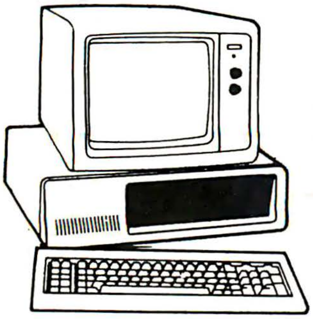
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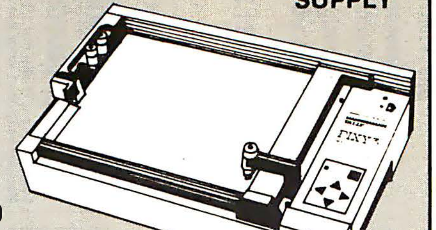
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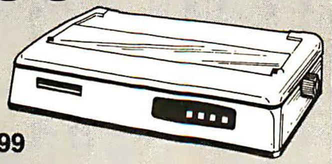
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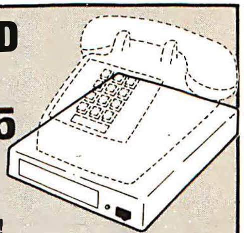
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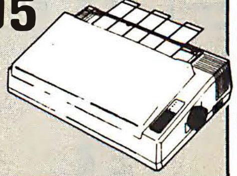
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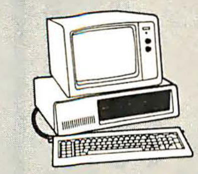
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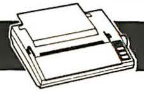
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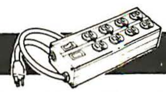
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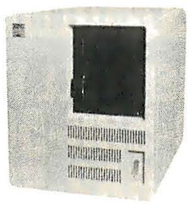
The **XAT** is out most versatile and powerful system. Using Intel's 80286 processor, the system runs at 6 and 8 MHz with a true 16-bit data bus. Comes standard with a 3 meg Add-On board, 2 parallel & one serial port, monitor, keyboard, DOS 3.1, two ½height DS DD 1.2 meg floppies.

XPC TURBO



This standard system is as compatible with IBM as it can be. Featuring a 4-layer motherboard, 8-slot expansion, up to 640K memory on the motherboard, and the 6.67 MHz ***TURBO*** mode. Also included: DOS 3.1, keyboard, 135 watt power supply, TTL 720 x 348 resolution video card, green or amber monitor, serial & parallel ports, Real Time Clock and software.

XTC TURBO



The perfect choice for the system integrator who needs the IBM compatibility, but not in the standard PC cabinet. This model features hinged and removable sides, up to 3 ½height peripherals out front, front mount AC switch and rear mount 135 watt power supply. Also makes an ideal "Host" or "File Server" unit in multi-user configurations!

XTjr.



The **XTjr.** is only junior in size! With up to 640K memory on the motherboard and four expansion slots, this stand-alone system is also great for workstations in a networking environment. It can be upgraded to the ***TURBO*** two speed motherboard and you can also add up to 2 serial & 2 parallel ports or any IBM compatible expansion card. A perfect word processing/data entry system.

XPC Compact



This is truly the affordable portable and well build it to your specifications. Need a 20 meg hard disk and 20 meg tape with 640K memory in your portable? No problem! The ***XPC Compact*** comes standard with a 9" amber TTL monitor, 135 watt P.S. 256K memory, two 360K drives, Real Time Clock Calendar w battery Back-up, serial and parallel ports, and our ***TURBO*** Motherboard.

Amsterdam ■ 020-45-26-50 — Germany ■

24 Add-On Cards

2 Meg Above Board



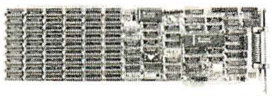
This board satisfies the new "Above Board" approach suggested by INTEL and Lotus 1-2-3. Also may be used on our **XT-SBC *TURBO*** board for memory based at 0K.

Hard Disk Controller



This Western Digital controller handles 1 or 2 drives, 5 to 140 megabytes with minimum software configuration. Features DOS 2.1 & 3.1 compatibility, and ST-506 Interface.

384K Multi-Function



A Multi-function board featuring Parallel Port, Serial Port, Game Port, Real Time Clock Calendar with Battery Back-up, Expand to 384K, all Cables, PrintSpooler and RAM Disk Software, and Manuals.

4 Meg Token Ring



Connect your workstation to an existing 4 Megabyte IBM token ring system or build up your own IEEE 802.5 standard system. The lowest possible cost for 100% industry standard compatibility.

AT H.D. & Floppy



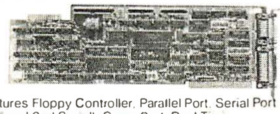
This new Western Digital combo board with its hi-speed VLSI technology will give you a data transfer rate 50% faster than the existing combo board in the AT. Runs both 360K and 1.2 meg floppy disk drives.

Mono & Color Graphics



Supports two levels of graphics and text in composite monochrome or RGB color. Low resolution 320 x 200 pixel, high resolution 640 x 200 pixel.

7 PAK Multi-Function



Features Floppy Controller, Parallel Port, Serial Port (optional 2nd Serial), Game Port, Real Time Clock Calendar with Battery Back-up, RAMdisk, Print-Spooler, all cables & manuals.

PROM Laser



Hi-speed algorithmes will burn 2716, 2732, 2732A, 2764 (in 52 sec), 27128, 27256 EPROMS under software control right in your PC. Zero Force Insertion Sockets, Software, and Manual.

England ■ — Bombay ■ 357172

35 Components

Motherboards

XAT *TURBO* — **XT-SBC**



- RTC Calendar
- 6 & 8 MHz clock
- 8-slot expansion
- Intel 80286

- 4.77 & 8 MHz clock
- Serial & Parallel
- 4-layer PCB design
- RTC Calendar

XPC *TURBO* — **XPC-XT**



- 4.77 & 6.67 MHZ
- 4-layer PCB design
- 8-slot expansion
- up to 640K Memory
- 8088-2 processor

- Standard 4.77 MHz
- up to 640K memory
- 8-slot expansion
- standard 8088 CPU
- 8087 socket avail

Power Supplys

XT 135 watt — **XT 150 watt**



- 135w switching
- Whisper Fan
- Side AC switch
- +5V-15A −5V-.5A
- +12V-4.2A −12V-.5A

- Whisper fan
- Hi-output 150 watt
- 4 DC connectors
- +5V-15A −5V-.5A
- +12V-5.5A −12V-.5A

AT 200 watt — **XTC 135**



- 200 Watt power
- Exterior AC switch
- 4 DC power conn
- +5V-20A −5V-.5A
- +12V-7.7A −12V-.5A

- Rear Mount
- Rear On Off switch
- extra AC outlets
- +5V-15A −5V-.5A
- +12V-4A −12V-.5A

Cabinets



The **XTjr.** cabinet is only 3" x 16.5" x 15" yet it will hold a standard XT compatible motherboard. Includes a switching power supply. Front panel cut-out for a half-height floppy or hard disk.



Our **XPC-XT** cabinet has an 8-slot back panel with additional cut-outs for two RS-232 I/O ports. Features mounting for up to four half height peripherals.



The right choice for an external add-on cabinet! Add-on a floppy, tape back-up, or up to 33 meg of hard disk (half-height). Switching power supply is included.

Keyboards

AT



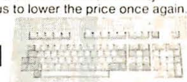
This Keyboard is standard equipment with all of our **XAT** systems, but the layout is so well liked, we're offering it here.

XT



Our volume purchases of these IBM style units allows us to lower the price once again.

5151



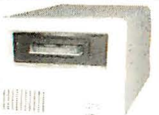
Now a fully selectric unit at an affordable price. Features a 10-key numeric pad & a separate cursor pad.

Drives



Archive
Irwin
Maxtor
Memtek
Miniscribe
Panasonic
Seagate
TEAC
Tulin

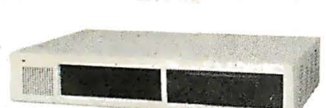
3 Sub-Systems



This full height cabinet will hold a Tape Back-up with full or ½height Hard Disk inside (or two Hard Disks)

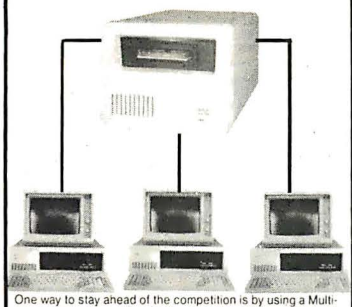


A perfect cabinet for Tape or Hard Disk, a nice addition to your PC



Choose from single ½height, dual ½height, or ½height with full height base. All Sub-systems include controllers, cables, software, and manuals.

3 Networks



One way to stay ahead of the competition is by using a Multi-User or Network system configuration from **Micro Products International**. Choose Hi-speed RS-232 · **XOR-NET SDLC** or Token Ring. Data transfer rates up to 4 megabytes second can be obtained.

Cassette Training



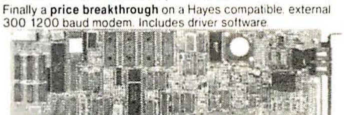
What is the Cassette Training concept? Using Interactive Audio Training to combine the advantage of classroom and self-teaching methods.
The Method . . . One audio track delivers a lecture explaining the program, while the second track emulates the keyboard, actually running the student's computer. At frequent intervals the tape pauses automatically to allow the student keyboard input, which is monitored for accuracy by the **MITS COED**.

Int/Ext Modems



- FCC approved for direct RJ-11 connection
- Phone Cable & Power Supply
- Runs the popular Hayes communications software

Finally a **price breakthrough** on a Hayes compatible, external 300/1200 baud modem. Includes driver software.



- **Q-Modem** software included. Also runs **XCOM** software
- All cables included
- Runs the popular Hayes communications software

We included every feature you would want in a modem card. It's FCC registered for direct connection to your modular phone jack with the cord included.

BUILD A COMPLETE XT SYSTEM—$698

STATIC RAMS

2101	256x4	(450ns)	1.95
5101	256x4	(450ns)(CMOS)	3.95
2102L-4	1024x1	(450ns)(LP)	.99
2102L-2	1024x1	(250ns)(LP)	1.45
2112	256x4	(450ns)	2.99
2114	1024x4	(450ns)	.99
2114L-4	1024x4	(450ns)(LP)	1.09
2114L-2	1024x4	(200ns)(LP)	1.49
2114L-15	1024x4	(150ns)(LP)	1.95
TMS4044-4	4096x1	(450ns)	1.95
TMM2016-150	2048x8	(150ns)	1.49
TMM2016-100	2048x8	(100ns)	1.95
HM6116-4	2048x8	(200ns)(CMOS)	1.39
HM6116-3	2048x8	(150ns)(CMOS)	1.49
HM6116LP-4	2048x8	(200ns)(CMOS)(LP)	1.49
HM6116LP-3	2048x8	(150ns)(CMOS)(LP)	1.59
HM6116LP-2	2048x8	(120ns)(CMOS)(LP)	2.95
HM6264P-15	8192x8	(150ns)(CMOS)	3.89
HM6264LP-15	8192x8	(150ns)(CMOS)(LP)	3.95
HM6264LP-12	8192x8	(120ns)(CMOS)(LP)	4.49

LP=Low power

DYNAMIC RAMS

4116-250	16384x1	(250ns)	.49
4116-200	16384x1	(200ns)	.69
4116-150	16384x1	(150ns)	.89
4116-120	16384x1	(120ns)	1.49
MK4332	32768x1	(200ns)	6.95
4164-200	65536x1	(200ns)(5V)	1.19
4164-150	65536x1	(150ns)(5V)	1.29
4164-120	65536x1	(120ns)(5V)	1.95
MCM6665	65536x1	(200ns)(5V)	1.95
TMS4164	65536x1	(150ns)(5V)	1.95
4164-REFRESH	65536x1	(150ns)(5V)(REFRESH)	2.95
TMS4416	16384x4	(150ns)(5V)	4.95
41128-150	131072x1	(150ns)(5V)	5.95
41256-200	262144x1	(200ns)(5V)	2.95
41256-150	262144x1	(150ns)(5V)	2.95

5V=Single 5 Volt Supply REFRESH=Pin 1 Refresh

★★★★HIGH-TECH★★★★

NEC V20 UPD70108 $14.95

REPLACES 8088 TO SPEED UP IBM PC 10-40%

- HIGH-SPEED ADDRESS CALCULATION IN HARDWARE
- PIN COMPATIBLE WITH 8088
- SUPERSET OF 8086/8088 INSTRUCTION SET
- LOW POWER CMOS

8 MHz	V20	UPD70108-8	$24.95
8 MHz	V30	UPD70116-8	$26.95

★★★★SPOTLIGHT★★★★

EPROMS

2708	1024x8	(450ns)	3.95
2716-6	2048x8	(650ns)	2.29
2716	2048x8	(450ns)(5V)	2.25
2716-1	2048x8	(350ns)(5V)	2.79
TMS2532	4096x8	(450ns)(5V)	3.95
2732	4096x8	(450ns)(5V)	2.45
2732A	4096x8	(250ns)(5V)(21V PGM)	2.75
2732A-2	4096x8	(200ns)(5V)(21V PGM)	3.95
27C64	8192x8	(250ns)(5V)(CMOS)	5.95
2764	8192x8	(450ns)(5V)	2.45
2764-250	8192x8	(250ns)(5V)	2.85
2764-200	8192x8	(200ns)(5V)	3.49
TMS2564	8192x8	(450ns)(5V)	8.95
MCM68766	8192x8	(350ns)(5V)(24 PIN)	17.95
27128	16384x8	(250ns)(5V)	2.79
27C256	32768x8	(250ns)(5V)(CMOS)	12.95
27256	32768x8	(250ns)(5V)	7.49

5V=Single 5 Volt Supply 21V PGM=Program at 21 Volts

ORDER TOLL FREE

800-538-5000

800-662-6279 (CA)

MasterCard VISA

SPECTRONICS CORPORATION — **EPROM ERASERS**



Model	Timer	Capacity Chip	Intensity (uW/Cm²)	Unit Price
PE-14	NO	9	8,000	$83.00
PE-14T	YES	9	8,000	$119.00
PE-24T	YES	12	9,600	$175.00

8000

8035	1.49
8039	1.95
8080	2.95
8085	2.49
8087-2	139.95
8087	109.00
8088	6.95
8088-2	9.95
8155	2.49
8155-2	3.95
8748	7.95
8755	19.95
80286	129.95
80287	185.00

8200

8203	29.95
8205	3.29
8212	1.49
8216	1.49
8224	2.25
8237	4.95
8237-5	5.49
8250	6.95
8251	1.69
8251A	1.89
8253	1.89
8253-5	1.95
8255	1.69
8255-5	1.89
8259	1.95
8259-5	2.29
8272	4.95
8279	2.49
8279-5	2.95
8282	3.95
8284	2.95
8286	3.95
8288	4.95

Z-80

Z80-CPU 2.5 MHz	1.69
4.0 MHz	
Z80A-CPU	1.79
Z80A-CTC	1.89
Z80A-DART	5.95
Z80A-DMA	5.95
Z80A-PIO	1.89
Z80A-SIO/0	5.95
Z80A-SIO/1	5.95
Z80A-SIO/2	5.95
6.0 MHz	
Z80B-CPU	3.75
Z80B-CTC	4.25
Z80B-PIO	4.25
Z80B-DART	14.95
Z80B-SIO/0	12.95
Z80B-SIO/2	12.95
Z8671 ZILOG	19.95

6500

1.0 MHz	
6502	2.79
65C02 (CMOS)	12.95
6507	9.95
6520	1.95
6522	4.95
6526	26.95
6532	6.95
6545	6.95
6551	5.95
6561	19.95
6581	34.95
2.0 MHz	
6502A	2.95
6520A	2.95
6522A	5.95
6532A	11.95
6545A	7.95
6551A	6.95
3.0 MHz	
6502B	6.95

6800

1.0 MHz	
6800	1.95
6802	4.95
6803	9.95
6809	5.95
6809E	5.95
6810	1.95
6820	2.95
6821	1.95
6840	6.95
6843	19.95
6844	12.95
6845	4.95
6847	11.95
6850	1.95
6883	22.95
2.0 MHz	
68B00	4.95
68B02	5.95
68B09E	6.95
68B09	6.45
68B21	3.50
68B45	6.75
68B50	3.95
68B54	7.95

CLOCK CIRCUITS

MM5369	1.95
MM5369-EST	1.95
MM58167	12.95
MM58174	11.95
MSM5832	2.95

CRT CONTROLLERS

6845	4.95
68B45	8.95
6847	11.95
HD46505SP	6.95
MC1372	2.95
8275	26.95
7220	19.95
CRT5027	12.95
CRT5037	9.95
TMS9918A	19.95

DISK CONTROLLERS

1771	4.95
1791	9.95
1793	9.95
1795	12.95
1797	12.95
2791	19.95
2793	19.95
2797	29.95
6843	19.95
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UPD765	4.95
MB8876	12.95
MB8877	12.95
1691	6.95
2143	6.95

BIT RATE GENERATORS

MC14411	9.95
BR1941	4.95
4702	9.95
COM8116	8.95
MM5307	4.95

UARTS

AY5-1013	3.95
AY3-1015	4.95
TR1602	3.95
2651	4.95
IM6402	6.95
IM6403	9.95
INS8250	6.95

SOUND CHIPS

76477	3.95
76489	8.95
SSI-263	39.95
AY3-8910	12.95
AY3-8912	12.95
SP1000	39.00

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32.768 KHz	.95
1.0 MHz	2.95
1.8432	2.95
2.0	1.95
2.097152	1.95
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3.2768	1.95
3.579545	1.95
4.0	1.95
4.032	1.95
5.0	1.95
5.0688	1.95
6.0	1.95
6.144	1.95
6.5536	1.95
8.0	1.95
10.0	1.95
10.738635	1.95
12.0	1.95
14.31818	1.95
15.0	1.95
16.0	1.95
17.430	1.95
18.0	1.95
18.432	1.95
20.0	1.95
22.1184	1.95
24.0	1.95
32.0	1.95

CRYSTAL OSCILLATORS

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1.8432	5.95
2.0	5.95
2.4576	5.95
2.5	4.95
4.0	4.95
5.0688	4.95
6.0	4.95
6.144	4.95
8.0	4.95
10.0	4.95
12.0	4.95
12.480	4.95
15.0	4.95
16.0	4.95
18.432	4.95
20.0	4.95
24.0	4.95

MISC.

TMS99531	9.95
TMS99532	19.95
ULN2003	.79
3242	7.95
3341	4.95
MC3470	1.95
MC3480	8.95
MC3487	2.95
11C90	13.95
2513-001 UP	6.95
AY5-2376	11.95
AY5-3600 PRO	11.95

74LS00

74LS00	.16	74LS165	.65
74LS01	.18	74LS166	.95
74LS02	.17	74LS169	.95
74LS03	.18	74LS173	.49
74LS04	.16	74LS174	.39
74LS05	.18	74LS175	.39
74LS08	.18	74LS191	.49
74LS09	.18	74LS192	.69
74LS10	.16	74LS193	.69
74LS11	.22	74LS194	.69
74LS12	.22	74LS195	.69
74LS13	.26	74LS196	.59
74LS14	.39	74LS197	.59
74LS15	.26	74LS221	.59
74LS20	.17	74LS240	.69
74LS21	.22	74LS241	.69
74LS22	.22	74LS242	.69
74LS27	.23	74LS243	.69
74LS28	.26	74LS244	.69
74LS30	.17	74LS245	.79
74LS32	.18	74LS251	.49
74LS33	.28	74LS253	.49
74LS37	.26	74LS256	1.79
74LS38	.26	74LS257	.39
74LS42	.39	74LS258	.49
74LS47	.59	74LS259	1.29
74LS48	.69	74LS260	.49
74LS51	.17	74LS266	.39
74LS73	.29	74LS273	.79
74LS74	.24	74LS279	.39
74LS75	.29	74LS280	1.98
74LS76	.29	74LS283	.59
74LS83	.49	74LS290	.89
74LS85	.49	74LS293	.89
74LS86	.22	74LS299	1.49
74LS90	.39	74LS322	3.95
74LS92	.49	74LS323	2.49
74LS93	.39	74LS364	1.95
74LS95	.49	74LS365	.39
74LS107	.34	74LS367	.39
74LS109	.36	74LS368	.39
74LS112	.29	74LS373	.79
74LS122	.45	74LS374	.79
74LS123	.49	74LS375	.95
74LS124	2.75	74LS377	.79
74LS125	.39	74LS378	1.18
74LS126	.39	74LS390	1.19
74LS132	.39	74LS393	.79
74LS133	.49	74LS541	1.49
74LS136	.39	74LS624	1.95
74LS138	.39	74LS640	.99
74LS139	.39	74LS645	.99
74LS145	.99	74LS669	1.29
74LS147	.99	74LS670	.89
74LS148	.99	74LS682	3.20
74LS151	.39	74LS683	3.20
74LS153	.39	74LS684	3.20
74LS154	1.49	74LS688	2.40
74LS155	.59	74LS783	22.95
74LS156	.49	81LS95	1.49
74LS157	.35	81LS96	1.49
74LS158	.29	81LS97	1.49
74LS160	.29	81LS98	1.49
74LS161	.39	25LS2521	2.80
74LS162	.49	25LS2569	2.80
74LS163	.39	26LS31	1.95
74LS164	.49	26LS32	1.95

HIGH SPEED CMOS

A new family of high speed CMOS logic featuring the speed of low power Schottky (8ns typical gate propagation delay), combined with the advantages of CMOS: very low power consumption, superior noise immunity, and improved output drive.

74HC00

74HC: Operate at CMOS logic levels and are ideal for new, all-CMOS designs.

74HC00	.59	74HC148	1.19
74HC02	.59	74HC151	.89
74HC04	.59	74HC154	2.49
74HC08	.59	74HC157	.89
74HC10	.59	74HC158	.95
74HC14	.79	74HC163	1.15
74HC20	.59	74HC175	.99
74HC27	.59	74HC240	1.89
74HC30	.59	74HC244	1.89
74HC32	.69	74HC245	1.89
74HC51	.59	74HC257	.85
74HC74	.75	74HC259	1.39
74HC85	1.35	74HC273	1.89
74HC86	.69	74HC299	4.99
74HC93	1.19	74HC368	.99
74HC107	.79	74HC373	2.29
74HC109	.79	74HC374	2.29
74HC112	.79	74HC390	1.39
74HC125	1.19	74HC393	1.39
74HC132	1.19	74HC4017	1.99
74HC133	.69	74HC4020	1.39
74HC138	.99	74HC4049	.89
74HC139	.99	74HC4050	.89

74HCT00

74HCT: Direct, drop-in replacements for LS TTL and can be intermixed with 74LS in the same circuit.

74HCT00	.69	74HCT166	3.05
74HCT02	.69	74HCT174	1.09
74HCT04	.69	74HCT193	1.39
74HCT08	.69	74HCT194	1.19
74HCT10	.69	74HCT240	2.19
74HCT11	.69	74HCT241	2.19
74HCT27	.69	74HCT244	2.19
74HCT30	.69	74HCT245	2.19
74HCT32	.79	74HCT257	.99
74HCT74	.85	74HCT259	1.59
74HCT75	.95	74HCT273	2.09
74HCT138	1.15	74HCT367	1.09
74HCT139	1.15	74HCT373	2.49
74HCT154	2.99	74HCT374	2.49
74HCT157	.99	74HCT393	1.59
74HCT158	.99	74HCT4017	2.19
74HCT161	1.29	74HCT4040	1.59
74HCT164	1.39	74HCT4060	1.49

74F00

74F00	.69	74F74	.79	74F251	1.69
74F02	.69	74F86	.99	74F253	1.69
74F04	.79	74F138	1.69	74F257	1.69
74F08	.69	74F139	1.69	74F280	1.79
74F10	.69	74F157	1.69	74F283	3.95
74F32	.69	74F240	3.29	74F373	4.29
74F64	.89	74F244	3.29	74F374	4.29

VISIT OUR RETAIL STORE LOCATED AT 1256 SOUTH BASCOM AVENUE IN SAN JOSE

JDR Microdevices

1224 S. Bascom Avenue, San Jose, CA 95128

800-538-5000 • 800-662-6279 (CA) • (408) 995-5430

FAX (408) 275-8415 • Telex 171-110

HOURS: M-W-F, 9-5 TU-TH, 9-9 SAT, 10-3

PLEASE USE YOUR CUSTOMER NUMBER WHEN ORDERING

TERMS: Minimum order $10.00. For shipping and handling include $2.50 for UPS Ground and $3.50 for UPS Air. Orders over 1 lb. and foreign orders may require additional shipping charges - please contact our sales department for the amount. CA. residents must include applicable sales tax. All merchandise is warranted for 90 days unless otherwise stated. Prices are subject to change without notice. We are not responsible for typographical errors. We reserve the right to limit quantities and to substitute manufacturer. All merchandise subject to prior sale.

PARTIAL LISTING ONLY — CALL FOR A FREE CATALOG

CMOS

4001	.19	14419	4.95
4011	.19	14433	14.95
4012	.25	4503	.49
4013	.35	4511	.69
4015	.29	4516	.79
4016	.29	4518	.85
4017	.49	4522	.79
4018	.69	4526	.79
4020	.59	4527	1.95
4021	.69	4528	.79
4024	.49	4529	2.95
4025	.25	4532	1.95
4027	.39	4538	.95
4028	.65	4541	1.29
4035	.69	4553	5.79
4040	.69	4585	.75
4041	.75	4702	12.95
4042	.59	74C00	.29
4043	.85	74C14	.59
4044	.69	74C74	.59
4045	1.98	74C83	1.95
4046	.69	74C85	1.49
4047	.69	74C95	.99
4049	.29	74C150	5.75
4050	.29	74C151	2.25
4051	.69	74C161	.99
4052	.69	74C163	.99
4053	.69	74C164	1.39
4056	2.19	74C192	1.49
4060	.69	74C193	1.49
4066	.29	74C221	1.75
4069	.19	74C240	1.89
4076	.59	74C244	1.89
4077	.29	74C374	1.99
4081	.22	74C905	10.95
4085	.79	74C911	8.95
4086	.89	74C917	8.95
4093	.49	74C922	4.49
4094	2.49	74C923	4.95
14411	9.95	74C926	7.95
14412	6.95	80C97	.95

7400/9000

7400	.19	74147	2.49
7402	.19	74148	1.20
7404	.19	74150	1.35
7406	.29	74151	.55
7407	.29	74153	.55
7408	.24	74154	1.49
7410	.19	74155	.75
7411	.25	74157	.55
7414	.49	74159	1.65
7416	.25	74161	.69
7417	.25	74163	.69
7420	.19	74164	.85
7423	.29	74165	.85
7430	.19	74166	1.00
7432	.29	74175	.89
7438	.29	74177	.75
7442	.49	74178	1.15
7445	.69	74181	2.25
7447	.89	74182	.75
7470	.35	74184	2.00
7473	.34	74191	1.15
7474	.33	74192	.79
7475	.45	74194	.85
7476	.35	74196	.79
7483	.50	74197	.75
7485	.59	74199	1.35
7486	.35	74221	1.35
7489	2.15	74246	1.35
7490	.39	74247	1.25
7492	.50	74248	1.85
7493	.35	74249	1.95
7495	.55	74251	.75
7497	2.75	74265	1.35
74100	2.29	74273	1.95
74121	.29	74278	3.11
74123	.49	74367	.65
74125	.45	74368	.65
74141	.65	9368	3.95
74143	5.95	9602	1.50
74144	2.95	9637	2.95
74145	.60	96S02	1.95

74S00

74S00	.29	74S163	1.29
74S02	.29	74S168	3.95
74S03	.29	74S174	.79
74S04	.29	74S175	.79
74S05	.29	74S188	1.95
74S08	.35	74S189	1.95
74S10	.29	74S195	1.49
74S15	.35	74S196	1.49
74S30	.29	74S197	1.49
74S32	.35	74S226	3.99
74S37	.69	74S240	1.49
74S38	.69	74S241	1.49
74S74	.49	74S244	1.49
74S85	.95	74S257	.79
74S86	.35	74S253	.79
74S112	.50	74S258	.95
74S124	2.75	74S280	1.95
74S138	.79	74S287	1.69
74S140	.55	74S288	1.69
74S151	.79	74S299	2.95
74S153	.79	74S373	1.69
74S157	.79	74S374	1.69
74S158	.95	74S471	4.95
74S161	1.29	74S571	2.95

DATA ACQ / INTERFACE

ADC0800	15.55	8T26	1.29
ADC0804	3.49	8T28	1.29
ADC0809	4.49	8T95	.89
ADC0816	14.95	8T96	.89
ADC0817	9.95	8T97	.59
ADC0831	8.95	8T98	.89
DAC0800	4.49	DM8131	2.95
DAC0806	1.95	DP8304	2.29
DAC0808	2.95	DS8833	2.25
DAC1020	8.25	DS8835	1.99
DAC1022	5.95	DS8836	.99
MC1408L8	2.95	DS8837	1.65

VOLTAGE REGULATORS

TO-220 CASE

7805T	.49	7905T	.59
7808T	.49	7908T	.59
7812T	.49	7912T	.59
7815T	.49	7915T	.59

TO-3 CASE

7805K	1.39	7905K	1.49
7812K	1.39	7912K	1.49

TO-92 CASE

78L05	.49	79L05	.69
78L12	.49	79L12	.69

OTHER VOLTAGE REGS

LM323K	5V 3A	TO-3	4.79
LM338K	Adj. 5A	TO-3	3.95
78H05K	5V 5A	TO-3	7.95
78H12K	12V 5A	TO-3	8.95
78P05K	5V 10A	TO-3	14.95

IC SOCKETS

	1-99	100
8 PIN ST	.11	.10
14 PIN ST	.11	.09
16 PIN ST	.12	.10
18 PIN ST	.15	.13
20 PIN ST	.18	.15
22 PIN ST	.15	.12
24 PIN ST	.20	.15
28 PIN ST	.22	.16
40 PIN ST	.30	.22
64 PIN ST	1.95	1.49

ST=SOLDERTAIL

8 PIN WW	.59	.49
14 PIN WW	.69	.52
16 PIN WW	.69	.58
18 PIN WW	.99	.90
20 PIN WW	1.09	.98
22 PIN WW	1.39	1.28
24 PIN WW	1.49	1.35
28 PIN WW	1.69	1.49
40 PIN WW	1.99	1.80

WW=WIREWRAP

16 PIN ZIF	4.95	CALL
24 PIN ZIF	5.95	CALL
28 PIN ZIF	6.95	CALL
40 PIN ZIF	9.95	CALL

ZIF=TEXTOOL (ZERO INSERTION FORCE)

LINEAR

TL066	.99	LM733	.98
TL071	.69	LM741	.29
TL072	1.09	LM747	.69
TL074	1.95	LM748	.59
TL081	.59	MC1330	1.69
TL082	.99	MC1350	1.19
TL084	1.49	MC1372	6.95
LM301	.34	LM1414	1.59
LM309K	1.25	LM1458	.49
LM311	.59	LM1488	.49
LM311H	.89	LM1489	.49
LM317K	3.49	LM1496	.85
LM317T	.95	LM1812	8.25
LM318	1.49	LM1889	1.95
LM319	1.25	ULN2003	.79
LM320	see7900	XR2206	3.75
LM322	1.65	XR2211	2.95
LM323K	4.79	XR2240	1.95
LM324	.49	MPQ2907	1.95
LM331	3.95	LM2917	1.95
LM334	1.19	CA3046	.89
LM335	1.40	CA3081	.99
LM336	1.75	CA3082	.99
LM337K	3.95	CA3086	.80
LM338K	3.95	CA3089	1.95
LM339	.59	CA3130E	.99
LM340	see7800	CA3146	1.29
LM350T	4.60	CA3160	1.19
LF353	.59	MC3470	1.95
LF356	.99	MC3480	8.95
LF357	.99	MC3487	2.95
LM358	.59	LM3900	.49
LM380	.89	LM3909	.98
LM383	1.95	LM3911	2.25
LM386	.89	LM3914	2.39
LM393	.45	MC4024	3.49
LM394H	4.60	MC4044	3.99
TL494	4.20	RC4136	1.25
TL497	3.25	RC4558	.69
NE555	.29	LM13600	1.49
NE556	.49	75107	1.49
NE558	1.29	75110	1.95
NE564	1.95	75150	1.95
LM565	.95	75154	1.95
LM566	1.49	75188	1.25
LM567	.79	75189	1.25
NE570	2.95	75451	.39
NE590	2.50	75452	.39
NE592	.98	75453	.39
LM710	.75	75477	1.29
LM723	.49	75492	.79

H=TO-5 CAN, K=TO-3, T=TO-220

EDGECARD CONNECTORS

100 PIN ST	S-100	.125	3.95
100 PIN WW	S-100	.125	4.95
62 PIN ST	IBM PC	.100	1.95
50 PIN ST	APPLE	.100	2.95
44 PIN ST	STD	.156	1.95
44 PIN WW	STD	.156	4.95

36 PIN CENTRONICS

MALE

IDCEN36	RIBBON CABLE	6.95
CEN36	SOLDER CUP	4.95

FEMALE

IDCEN36/F	RIBBON CABLE	7.95
CEN36PC	RT ANGLE PC MOUNT	4.95

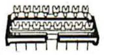
INTERSIL

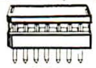
ICL7106	9.95
ICL7107	12.95
ICL7660	2.95
ICL8038	4.95
ICM7207A	5.95
ICM7208	15.95

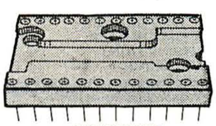
DIP CONNECTORS

DESCRIPTION	ORDER BY	CONTACTS 8	14	16	18	20	22	24	28	40
HIGH RELIABILITY TOOLED ST IC SOCKETS	AUGATxxST	.62	.79	.89	1.09	1.29	1.39	1.49	1.69	2.49
HIGH RELIABILITY TOOLED WW IC SOCKETS	AUGATxxWW	1.30	1.80	2.10	2.40	2.50	2.90	3.15	3.70	5.40
COMPONENT CARRIES (DIP HEADERS)	ICCxx	.49	.59	.69	.99	.99	.99	.99	1.09	1.49
RIBBON CABLE DIP PLUGS (IDC)	IDPxx	---	.95	.95	---	---	---	1.75	---	2.95

FOR ORDERING INSTRUCTIONS SEE D-SUBMINIATURE BELOW


ICC16


IDP14


AUGAT 24ST

DIODES/OPTO/TRANSISTORS

1N751	.25	4N26	.69
1N759	.25	4N27	.69
1N4148	25/1.00	4N28	.69
1N4004	10/1.00	4N33	.89
1N5402	.25	4N37	1.19
KBP04	.55	MCT-2	.59
KBU8A	.95	MCT-6	1.29
MDA990-2	.35	TIL-111	.99
N2222	.25	2N3906	.10
PN2222	.10	2N4401	.25
2N2905	.50	2N4402	.25
2N2907	.25	2N4403	.25
2N3055	.79	2N6045	1.75
2N3904	.10	TIP31	.49

D-SUBMINIATURE

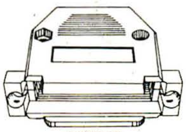
DESCRIPTION		ORDER BY	CONTACTS 9	15	19	25	37	50
SOLDER CUP	MALE	DBxxP	.82	.90	1.25	1.25	1.80	3.48
	FEMALE	DBxxS	.95	1.15	1.50	1.50	2.35	4.32
RIGHT ANGLE PC SOLDER	MALE	DBxxPR	1.20	1.49	---	1.95	2.65	---
	FEMALE	DBxxSR	1.25	1.55	---	2.00	2.79	---
WIRE WRAP	MALE	DBxxPWW	1.69	2.56	---	3.89	5.60	---
	FEMALE	DBxxSWW	2.76	4.27	---	6.84	9.95	---
IDC RIBBON CABLE	MALE	IDBxxP	2.70	2.95	---	3.98	5.70	---
	FEMALE	IDBxxS	2.92	3.20	---	4.33	6.76	---
HOODS	METAL	MHOODxx	1.25	1.25	1.30	1.30	---	---
	GREY	HOODxx	.65	.65	---	.65	.75	.95

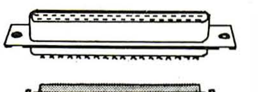
ORDERING INSTRUCTIONS: INSERT THE NUMBER OF CONTACTS IN THE POSITION MARKED "xx" OF THE "ORDER BY" PART NUMBER LISTED.

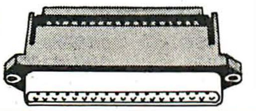
EXAMPLE: A 15 PIN RIGHT ANGLE MALE PC SOLDER WOULD BE DB15PR.

MOUNTING HARDWARE $1.00


MTG HDWR


HOOD25


DB37S


IDB37S

LED DISPLAYS

FND-357(359)	COM CATHODE	.362"	1.25
FND-500(503)	COM CATHODE	.5"	1.49
FND-507(510)	COM ANODE	.5"	1.49
MAN-72	COM ANODE	.3"	.99
MAN-74	COM CATHODE	.3"	.99
MAN-8940	COM CATHODE	.8"	1.99
TIL-313	COM CATHODE	.3"	.45
HP5082-7760	COM CATHODE	.43"	1.29
TIL-311	4x7 HEX W/LOGIC	.270"	9.95
HP5082-7340	4x7 HEX W/LOGIC	.290"	7.95

DIFFUSED LEDS

		1-99	100-UP
JUMBO RED	T1¾	.10	.09
JUMBO GREEN	T1¾	.14	.12
JUMBO YELLOW	T1¾	.14	.12
MOUNTING HDW	T1¾	.10	.09
MINI RED	T1	.10	.09

SWITCHES

SPST	MINI-TOGGLE ON-ON	1.25
DPDT	MINI-TOGGLE ON-ON	1.50
DPDT	MINI-TOGGLE ON-OFF-ON	1.75
SPST	MINI-PUSHBUTTON N.O.	.39
SPST	MINI-PUSHBUTTON N.C.	.39
SPST	TOGGLE ON-OFF	.49
BCD OUTPUT 10 POSITION 6 PIN DIP		1.95

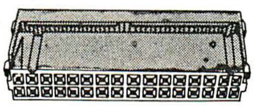
DIP SWITCHES

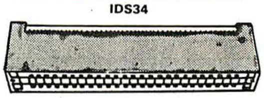
4 POSITION	.85	7 POSITION	.95
5 POSITION	.90	8 POSITION	.95
6 POSITION	.90	10 POSITION	1.29

IDC CONNECTORS

DESCRIPTION	ORDER BY	CONTACTS 10	20	26	34	40	50
SOLDER HEADER	IDHxxS	.82	1.29	1.68	2.20	2.58	3.24
RIGHT ANGLE SOLDER HEADER	IDHxxSR	.85	1.35	1.76	2.31	2.72	3.39
WW HEADER	IDHxxW	1.86	2.98	3.84	4.50	5.28	6.63
RIGHT ANGLE WW HEADER	IDHxxWR	2.05	3.28	4.22	4.45	4.80	7.30
RIBBON HEADER SOCKET	IDSxx	.79	.99	1.39	1.59	1.99	2.25
RIBBON HEADER	IDMxx	---	5.50	6.25	7.00	7.50	8.50
RIBBON EDGE CARD	IDExx	1.75	2.25	2.65	2.75	3.80	3.95

FOR ORDERING INSTRUCTIONS SEE D-SUBMINIATURE ABOVE


IDS34


IDE50

RIBBON CABLE

CONTACTS	SINGLE COLOR 1'	SINGLE COLOR 10'	COLOR CODED 1'	COLOR CODED 10'
10	.18	1.60	.30	2.75
16	.28	2.50	.48	4.40
20	.36	3.20	.60	5.50
25	.45	4.00	.75	6.85
26	.46	4.10	.78	7.15
34	.61	5.40	1.07	9.35
40	.72	6.40	1.20	11.00
50	.89	7.50	1.50	13.25

HARD TO FIND "SNAPABLE" HEADERS

CAN BE SNAPPED APART TO MAKE ANY SIZE HEADER, ALL WITH .1" CENTERS

1x40	STRAIGHT LEAD	.99
1x40	RIGHT ANGLE	1.49
2x40	STRAIGHT LEAD	2.49
2x40	RIGHT ANGLE	2.99

SHORTING BLOCKS

GOLD CONTACTS SPACED AT .1" CENTERS



5/$1.00

It was a pleasure to place an order with your people. I found the response pleasant and helpful and the answers prompt and correct. The delivery on my most recent order was fast, correct and well packed. I already had faith in the quality since my family has been using some of your products for several years with no problems.

Sincerely, J.D. Hattaway

CALL FOR VOLUME QUOTES

ORDER TOLL FREE **800-538-5000** **800-662-6279** (CA)

BARGAIN HUNTERS CORNER

FRANKLIN ACE-10

DISK DRIVE FOR APPLE II

- ★ RELIABLE, DIRECT DRIVE MECHANISM MADE FOR FRANKLIN BY MITAC, A WORLD LEADER IN FDDs FOR APPLE
- ★ 100% COMPATIBLE WITH APPLE II, II+, AND IIe; USE W/STANDARD APPLE CONTROLLER OR OPTIONAL $49.95 CONTROLLER
- ★ FULL HEIGHT BEIGE ENCLOSURE MATCHES APPLE; BAKED ENAMEL FINISH RESISTS SCRATCHES
- ★ SHIELDED CABLE WITH GROUNDING LUG FOR EMI-FREE OPERATION

ONE YEAR WARRANTY

ONLY $79.95

HURRY — QUANTITIES ARE LIMITED!

SPECIALS END 4/30/86

PAGE WIRE WRAP WIRE

PRECUT ASSORTMENT
IN ASSORTED COLORS $27.50
100ea: 5.5", 6.0", 6.5", 7.0"
250ea: 2.5", 4.5", 5.0"
500ea: 3.0", 3.5", 4.0"

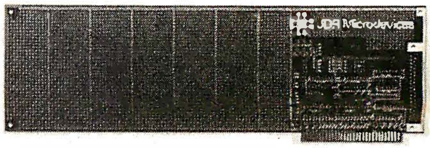
SPOOLS

100 feet	$4.30	250 feet	$7.25
500 feet	$13.25	1000 feet	$21.95

Please specify color: Blue, Black, Yellow or Red

WIRE WRAP PROTOTYPE CARDS

FR-4 EPOXY GLASS LAMINATE
WITH GOLD-PLATED EDGE-CARD FINGERS



IBM-PR2

IBM

BOTH CARDS HAVE SILK SCREENED LEGENDS AND INCLUDES MOUNTING BRACKET

IBM-PR1	WITH +5V AND GROUND PLANE	$27.95
IBM-PR2	AS ABOVE WITH DECODING LAYOUT	$29.95

S-100

P100-1	BARE - NO FOIL PADS	$15.15
P100-2	HORIZONTAL BUS	$21.80
P100-3	VERTICAL BUS	$21.80
P100-4	SINGLE FOIL PADS PER HOLE	$22.75

APPLE

P500-1	BARE - NO FOIL PADS	$15.15
P500-3	HORIZONTAL BUS	$22.75
P500-4	SINGLE FOIL PADS PER HOLE	$21.80
7060-45	FOR APPLE IIe AUX SLOT	$30.00

EMI FILTER $4.95

- MANUFACTURED BY CORCOM
- LOW COST
- FITS LC-HP BELOW
- 6 AMP 120/240 VOLT



6 FOOT LINE CORDS

LC-2	2 CONDUCTOR	.39
LC-3	2 CONDUCTOR	.99
LC-HP	3 CONDUCTOR W/STD FEMALE SOCKET	1.49

MUFFIN FANS

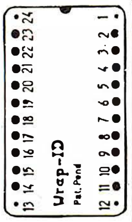
3.15" SQ	ROTRON	14.95
3.63" SQ	ETRI	14.95
3.18" SQ	MASUSHITA	16.95

SOCKET-WRAP I.D.™

- SLIPS OVER WIRE WRAP PINS
- IDENTIFIES PIN NUMBERS ON WRAP SIDE OF BOARD
- CAN WRITE ON PLASTIC; SUCH AS IC #

PINS	PART#	PCK. OF	PRICE
8	IDWRAP 08	10	1.95
14	IDWRAP 14	10	1.95
16	IDWRAP 16	10	1.95
18	IDWRAP 18	5	1.95
20	IDWRAP 20	5	1.95
22	IDWRAP 22	5	1.95
24	IDWRAP 24	5	1.95
28	IDWRAP 28	5	1.95
40	IDWRAP 40	5	1.95

PLEASE ORDER BY NUMBER OF PACKAGES (PCK. OF)

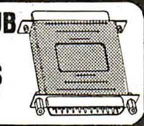


ID WRAP 24

FRAME STYLE TRANSFORMERS

12.6V AC CT	2 AMP	5.95
12.6V AC CT	4 AMP	7.95
12.6V AC CT	8 AMP	10.95
25.2V AC CT	2 AMP	7.95

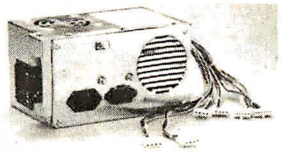
25 PIN D-SUB GENDER CHANGERS $7.95



SWITCHING POWER SUPPLIES

PS-IBM $99.95

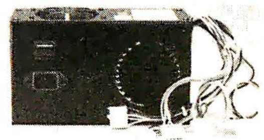
- FOR IBM PC-XT COMPATIBLE
- 135 WATTS
- +5V @ 15A, +12V @ 4.2A -5V @ .5A, -12V @ .5A
- ONE YEAR WARRANTY



PS-IBM

PS-IBM-150 $129.95

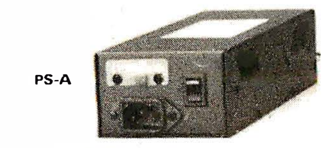
- FOR IBM PC-XT COMPATIBLE
- 150 WATTS
- +12V @ 5.2A, +5V @ 16A -12V @ .5A, -5V @ .5A
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PS-130

PS-130 $99.95

- 130 WATTS
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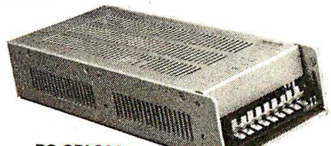
PS-A

PS-A $49.95

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- UL APPROVED
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PS-SPL200

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TANTALUM

1.0µf	15V	.35	.47µf	35V	.45
6.8	15V	.70	1.0	35V	.45
10	15V	.80	2.2	35V	.65
22	15V	1.35	4.7	35V	.85
.22	35V	.40	10	35V	1.00

DISC

10pf	50V	.05	680	50V	.05
22	50V	.05	.001µf	50V	.05
27	50V	.05	.0022	50V	.05
33	50V	.05	.005	50V	.05
47	50V	.05	.01	50V	.07
68	50V	.05	.02	50V	.07
100	50V	.05	.05	50V	.07
220	50V	.05	.1	12V	.10
560	50V	.05	.1	50V	.12

MONOLITHIC

.01µf	50V	.14	.1µf	50V	.18
.047µf	50V	.15	.47µf	50V	.25

ELECTROLYTIC

RADIAL			AXIAL		
1µf	25V	.14	1µf	50V	.14
2.2	35V	.15	10	50V	.16
4.7	50V	.15	22	16V	.14
10	50V	.15	47	50V	.20
47	35V	.18	100	35V	.25
100	16V	.18	220	25V	.30
220	35V	.20	470	50V	.50
470	25V	.30	1000	16V	.60
2200	16V	.70	2200	16V	.70
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.1 µf MONOLITHIC	100/$12.50

BOOKS BY STEVE CIARCIA

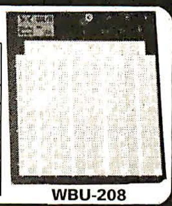
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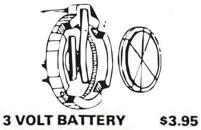
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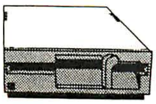
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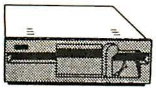
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FOR APPLE COMPUTERS

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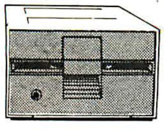
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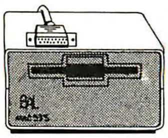
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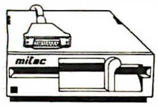
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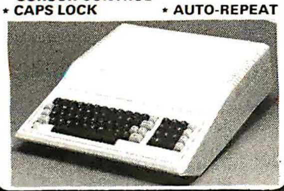
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CASE WITH KEYBOARD FOR APPLE TYPE MOTHERBOARD

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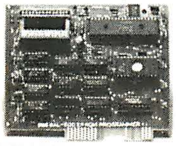
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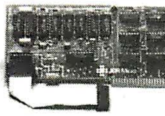
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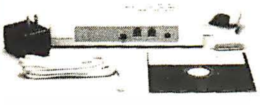
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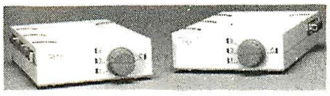
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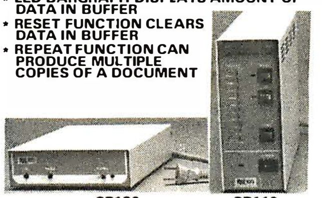
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- LED INDICATOR SHOWS VOLUME OF DATA IN BUFFER

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SP120 SP110

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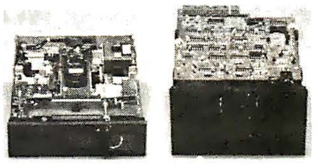
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TEAC FD-55 TANDON TM100-2

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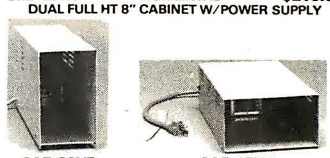
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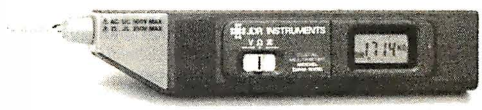


CAB-2SV5 CAB-1FH5

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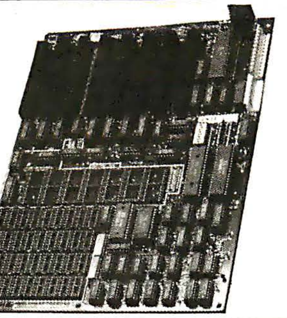
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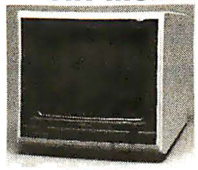
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- DB25 TO CENTRONICS
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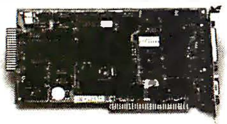
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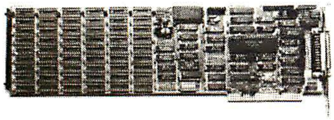
PERFECT FOR THE 640K MOTHERBOARD



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- GAME PORT
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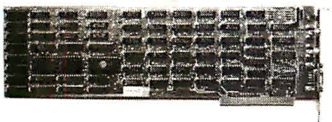


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- PARALLEL PORT
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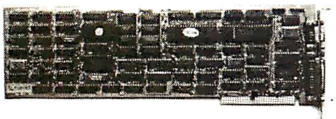
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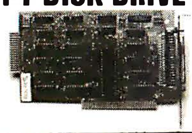
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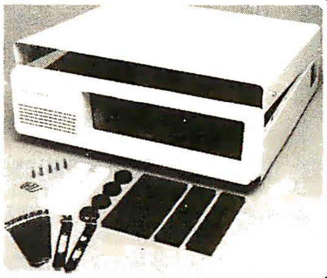
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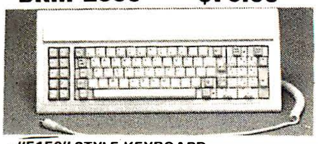
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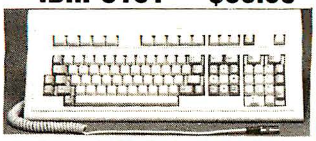
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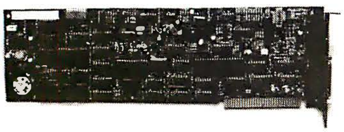
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Inquiry 175

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WANTED: Nonprofit agency for learning-disabled children seeks tax-deductible donation of Apple II+ or IIe computer with CP/M and printer. Will provide receipts. California Center for Educational Therapy, 6016 Fallbrook Ave., Suite 201, Woodland Hills, CA 91367, (818) 347-2600.

NEEDED: Nonprofit organization providing community-based services for the elderly in rural Vermont needs donation of IBM PC or compatible. Low-cost, volunteer-oriented agency serves elders in economic need. Tax-deductible. Will pay shipping. James Matteau, Council on Aging for Southeastern Vermont, POB 818, Brattleboro, VT 05301.

NEEDED: Used Apple II computers. The United Blind of Washington State will take your Apple, add a speech synthesizer, instruct a blind person, and loan it to him/her for as long as necessary. Tax-deductible. Frank Cuta, Route 2, Box 2554C, Benton City, WA 99320, (509) 967-2658.

WANTED: The Correctional Education Institute (CEI) of California seeks nonprofit donations of computers, literature, and public-domain software for the vocational EDP program. Alan Clute, 253 Martens Ave. #7, Mountain View, CA 94040, (415) 965-2591.

WANTED: Nonprofit organization for wildlife and habitat preservation seeks tax-deductible donation of Kaypro 2000 with disk drive or similar battery-operated IBM PC-compatible. Also seeking battery-operated printer. Located in remote region; have only photovoltaic power. Resources Limited, Whale Buttes Rd., Polebridge, MT 59928.

WANTED: Nonprofit laboratory studying Appalachian natural history seeks donation of computer system for word processing, statistics, and business applications. Tax-deductible. Dr. George Constantz, Pine Cabin Run Ecological Laboratory, High View, WV 26808, (304) 856-3911 or 822-5016.

NEEDED: Nonprofit group that teaches people about protecting their water resources seeks tax-deductible donation of IBM PC or compatible with 256K RAM, disk drive(s), monitor, and printer. Will provide receipts. National Water Center, POB 548, Eureka Springs, AR 72632, (501) 253-9755.

WANTED: Computer pen pals or clubs with whom I can exchange public-domain software, books, and manuals on the Spectrum computer. Charudatt Uplap, A/13, Kerala Nagar, Tagore Rd., Santacruz (W), Bombay–400 054, India.

FOR SALE: Xerox 820 motherboard, 64K RAM, floppy-disk controller, 80 by 24 video, two RS-232C ports, and two parallel ports. Includes power supply and manual. $150 or trade on HP 41CV. PC board for 8086 kit from Intel, fully socketed, includes manual: $55. Dennis Griffith, 6816 Louisiana Dr., Vancouver, WA 98664, (206) 695-3006.

WANTED: Correspondence with Coleco Adam users. Also wanted: public-domain astrology and biorhythm programs for Adam. Linda Harold, POB 8147, Sacramento, CA 95818, (916) 451-9332.

WANTED: A copy of the *Attache Technical Manual*. Would also like information on public-domain applications and utility software. David C. Vaughn, 313 East 5th St., Bethlehem, PA 18015, (215) 536-4660.

FOR SALE: IMSAI 8080 mainframe with 4-MHz Z80A and 2-MHz 8080 processors, 40K static RAM, three parallel and serial I/O board, VDM-1 64 by 16 video card with monitor, 9918A color-graphics board, and more. $900. Robert Kunzig, 934 North Orange St., Media, PA 19063, (215) 565-7761.

FOR SALE: Complete set of BYTE. $350. Buyer pays shipping. K. Meyer, 4906 Cottonwood Lane, Salt Lake City, UT 84117, (801) 277-9320.

FOR SALE: Sanyo MBC-555-2 with 128K RAM, two DS/DD drives, and more. $725. Paul J. Konitzer, 3856 Clark St., Seaford, NY 11783, (516) 783-7274.

FOR SALE: Seattle Computer Products S-100 board set. 8086 8-MHz CPU, floppy-disk controller, I/O board with two serial, one parallel, MS-DOS 2.1.: $700. Lexicomp 128K 8-MHz static RAM: $300. A. Paulsen, 27 Alhambra #201, San Francisco, CA 94123, (415) 921-8513.

FOR SALE: BYTE, September 1975 through August 1985: $250. *Kilobaud*, January 1977 through November 1984: $100. *Popular Electronics*, October 1981 through April 1985: $50. Other publications available. Will sell sets only. Send SASE. G. Sabionski, 3203 Cedarmont, LaPorte, TX 77571.

FOR SALE: BYTE: February 1981 through February 1985 complete plus June 1980 and 1984 IBM PC issue. $135 or best offer. Will ship COD via UPS. Sam Wilkinson III, POB 140810, Dallas, TX 75214.

FOR SALE: CompuPro 816/A, 8085/88 CPU, 256K RAM, system support, two 8-inch floppy-disk drives (1.2 megabytes each), Interfacer 4, Disk 1, Heath H-29 terminal, and more. Greg Puckett, 3235 Buell St., Cincinnati, OH 45211.

FOR SALE: Ohio Scientific OSI-C8P, 32K, dual 8-inch floppy drives, parallel and serial interfaces, VT200 auto-dial/auto-answer, RF (TV) converter, manuals, and more. Asking $1500. Rich McLean, 357 Walker Rd., Great Falls, VA 22066, (703) 759-4840.

WANTED: Radio Shack TRS-80 Model II computer with 64K RAM. Other Model II accessories. Send description and price. John E. Thornton, Route 1, Box 276, White Plains, MD 20695.

FOR SALE: Estimator contractor's estimating computer with wands and disk drive. Originally $20,000. Looking for offers over $1000. Barry Barton, Box 9259, Coral Springs, FL 33075, (305) 752-3714.

FOR SALE: Apparat 512K RAM Card (64K installed) with printer spooler. Apparat Combo card with clock, parallel, serial, and game ports. Either one for $100 or $180 for both, postage paid. J. Lee, 731 Navajo St., Socorro, NM 87801, (505) 835-6051.

FOR SALE: 32K S-100 static RAM boards with memory-protect and incremental 4K-boundary DIP switch select. Also, TMS-4044 chips and LSI ADM 3A built from kit with chips in sockets. Steve Fritts, POB 1543, Beaver Falls, PA 15010, (412) 846-5979.

FOR SALE: Hewlett-Packard Portable computer, #45710A. Never used, includes all warranty information, manuals, etc. Asking $1300. James Frey, POB 70, Chester, NJ 07930, (201) 879-6180.

FOR SALE: Osborne Executive with dual SS/DD disk drives, 7½-inch amber monitor, Gorilla Banana Printer with 2000 sheets of printer paper, and more. $2000 or best offer. Steve L. Geries, POB 636, Farwell, TX 79325, (806) 481-9981.

FOR SALE: IBM Office System 6 with power supply, 12K memory, all ROMs, 8-inch SS/SD disk drive, keyboard, tilt/swivel monitor, and more. $800 or best offer. Robert Hargrove, Rt. 2, Box 2040, McAllen, TX 78504, (512) 686-5219.

FOR SALE: Apple I computer; a collector's item. A 1976 original with cassette and video interface. Runs Apple I BASIC. Also comes with original manual. Best offer. Dave Selinger, 1619 Willowspring Dr., Encinitas, CA 92024, (619) 436-3135.

FOR SALE: Commodore VIC-20 computer. $100. David Knowles, 20 Sarah St., Burlington, MA 01803.

FOR SALE: Hewlett-Packard ThinkJet printer; excellent condition. $300. R. H. Loyer, 3 Campus Court, Trenton, NJ 08638.

FOR SALE: BYTE: 1983 through 1985 at $30 per year, postage paid. Single issues from June 1982 through December 1982 at $3 each. John Stokes, 7910 South Memorial Parkway, Suite H, Huntsville, AL 35802, (205) 882-2360.

FOR SALE: Unused 87-key parallel-encoded keyboard (comes with specs): $90. IBM PC XT motherboard with resistors, capacitors, sockets, and more: $195. Mark Thomas, 7001 Kingfisher Lane, Lanham, MD 20706, (301) 552-3665.

FOR SALE: TRS-80 Model I, 48K, with expansion, serial port, and more. Asking $500. P. French, POB 2441, Laguna Hills, CA 92654.

UNCLASSIFIED ADS MUST *be noncommercial, from readers who have computer equipment to buy, sell, or trade on a onetime basis. All requests for donated computer equipment must be from nonprofit organizations. Programs to be exchanged must be written by the individual or be in the public domain. Ads must be typed double-spaced, contain 50 words or less, and include full name and address. This is a free service; ads are printed as space permits.* BYTE *reserves the right to reject any unclassified ad that does not meet these criteria. When you submit your ad* (BYTE, *Unclassified Ads*, POB 372, *Hancock*, NH 03449), *allow at least four months for it to appear.*

FOR SALE: IBM Monochrome Display: $135. IBM Display Adapter card with printer port: $135. IBM Game Adapter card: $25. IBM Async Adapter (serial) card: $50. Hayes 300-bps modem: $140. Paul Silagi, 130 Nutmeg Lane #336, East Hartford, CT 06118, (203) 568-7126.

FOR SALE: BYTE: two sets of 1977 issues. Will sell separately at $4 each or in sets. Charles Markham, POB 54, MIT Branch, Cambridge, MA 02139.

FOR SALE: Hewlett-Packard HP 110 Portable computer. Battery-powered, 384K ROM, 272K RAM, built-in modem, Thinklet printer, 3½-inch disk drive. $4000. Gregory Harrison, 875 Derbyshire Rd. #223, Daytona Beach, FL 32017, (904) 252-7647.

FOR SALE: First 16 issues of BYTE in good condition. $110. Gerald A. Block, 525 North Spoonbill Dr., Sarasota, FL 33577, (813) 955-9087.

FOR SALE: Osborne I with dual double-density disk drives and collection of First Osborne User Group public-domain software: $600. Tandon TM 100-4 disk drive with cabinet and power supply: $59. Other equipment available. Ed Hochman, 86 Overhill Rd., Stamford, CT 06902, (203) 322-3619.

FOR SALE: Taxan RGB Vision II monitor: $250. Zenith ZVM-123 monitor: $65. Columbia color graphics board: $75. Crawford Best, 311 Magnolia Dr., Metairie, LA 70005, (504) 835-1798.

FOR SALE: Victor 9000 computer with 2 disk drives, high-resolution monitor, MS-DOS, CP/M-86, and programmable keyboard: $1700. Laura Clark, 231 Quincy St., Hancock, MI 49930, (906) 482-8260.

FOR SALE: 64K RAM CompuPro with 12-slot motherboard, power supply, two Shugart 801 SS/DD 8-inch disk drives, Visual V200 terminal, US Robotics password 300/1200-bps modem, and more. Best offer over $1400. Tom Serkowski, 644 North Enid, Covina, CA 91722, (818) 332-3273.

FOR SALE: IBM PC AT with 896K RAM, 33-megabyte hard disk, monitor, Paradise Modular Graphics Card, AST Research Advantage board: $5700. R. Nels Nelson, Box 158, Loris, SC 29569, (803) 756-6060.

FOR SALE: Motorola 68000 VERSAbus system with CPU, 512K RAM, multichannel I/O, universal disk controller, 13-megabyte disk, card cage, and power supplies. $1200. Hugh Shane, POB 45292, Seattle, WA 98145, (206) 523-4235.

FOR SALE: Used 64K 80-column extended card for Apple IIe: $30. I will pay shipping. Chan Sui Wa, POB 35643, King's Road Post Office, Hong Kong.

FOR SALE: CompuPro 816/C with 192K RAM, TeleVideo 950 terminal, Interfacer 4, Disk 1, modem, and more. $4000. Russ Davis, 2520 Cartier Court, Fairfield, CA 94533, (707) 429-1382.

FOR SALE: Hewlett-Packard HP 86A, monitor, two HP 9130A drives, and documentation. Excellent condition. W. G. O'Brien, 104 Michaels Dr., Dewitt, NY 13214, (315) 446-4424.

FOR SALE: TI 850 printer with tractor and friction feed. Great condition. Asking $450. I will pay shipping. Jim Ward, 9012 Cypress Point Lane, Cincinnati, OH 45249, (513) 683-5816.

FOR SALE: BYTE: March 1978 through December 1985. Also, Apple cards with manuals: Heuristics Speechlab voice-recognition card with microphone; Mountain Hardware Introl remote control system card with dual-channel AC remote box. Make offer. Dale Bartholomew, 22405 Northeast 20th St., Redmond, WA 98053.

FOR SALE: Zenith ZF-151-21; excellent condition. Asking $1400. A. M. Johnson, 81 North Ridge Rd., Ipswich, MA 01938.

FOR SALE: Three 256K RAM boards and one 512K RAM board for TRS-80 Model 16. Best offer. Barbara, Carpenter & Associates, 510 South Congress, Suite 400, Austin, TX 78704, (512) 477-4002.

FOR SALE: CompuPro 8085/88 system with CP/M-86, CP/M-80, 320K RAM, two 8-inch drives, 9 serial ports, and more. Make offer. Talbot Jaeger, 11162 Tarawa Dr., Los Alamitos, CA 90720, (213) 493-4813.

FOR SALE: OSI C4P-MF computer with one drive and 24K. Good second machine for established OSI user. $1000. David Shapiro, 5294 Vista del Sol, Cypress, CA 90630.

WANTED: Italian student wishes to correspond with Apple II users to discuss hardware and applications. Francesco Ceccatelli, via G.Monaco 92, 52100 Arezzo, Italy. ■

B·O·M·B

BYTE's Ongoing Monitor Box

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BOMB *Results*

A GOOD START

The Product Description of "The Atari 520ST" by BYTE staffers Jon R. Edwards, Phillip Robinson, and Brenda McLaughlin is the winning article from January's issue. In second place is Steve Ciarcia's Circuit Cellar: "Build an Analog-to-Digital Converter." Jerry Pournelle wins third place with "One Minor Problem" while Computing at Chaos Manor. What's New came in fourth. In fifth place and the winner of $100 is Kirk E. Pennywitt's "Robotic Tactile Sensing" about sophisticated sensory capabilities. In sixth place and the winner of the $50 prize for writing the second-placed nonstaff-written article is Henning Mittelbach for his Programming Insight entitled "Easy 3-D Graphics." Congratulations to all of these authors.

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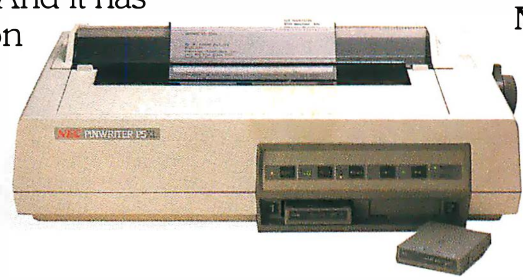
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